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EROSION: A REAL MENACE IN THE SOUTHWEST[1]

By B. P. FLEMING

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THAT erosion by wind and water is the principal factor in giving character to the topography of the Southwest is familiar to any one who has lived or traveled in this region. Accelerated erosion by winds and water due to man's comparatively recent occupation of the Southwest is not so generally recognized as responsible for profound changes in topography. Nevertheless, it is generally admitted and believed that the problem of erosion in the Southwest had its beginning coincident with our Anglo-Saxon occupation of this region. Marked vegetative changes have occurred on the vast ranges used for grazing. Box canyons and deep arroyos are now found where some of the early settlers located their home ranches, river beds have risen and adjoining areas of once fine agricultural lands have become water-logged and alkalied.

Arroyo floods and the debris swept along the arroyos by these floods and deposited at the mouth of the arroyos in the form of great delta fans are responsible for the loss of many thousands of acres of lands in the river valleys, while the choking of culverts and flood passages beneath bridges by arroyo debris greatly increases the problem of maintenance of railroads and highways.

Many of us are inclined to the view that the melancholy results of accelerated erosion, which are so evident in many parts of our Southwest are to some extent, if not wholly, due to man's occupation and exploitation of this region. In confirmation of this view we have the evidence of old settlers and the physical evidence which we are free to interpret ourselves. In the valleys below Elephant Butte Reservoir we have probably one of the oldest inhabited regions of the Southwest. It has supported some sort of civilization for much over 300 years. Prior to the coming of the white man, it was occupied by the villages of the pueblo type Indian. Some of

[1] Address at the thirteenth annual meeting of the Southwestern Division of the American Association for the Advancement of Science, Las Cruces, New Mexico, May 1 to 4, 1933.

their villages exist to this day. They were built almost always on the edges of the mesa above the flood plain of the Rio Grande, a turbulent stream which, prior to its curbing by storage, wandered at will back and forth across the valley, occupying this year a channel on this side of the valley, but next year one perhaps against the mesa on the other side.

The Indians had great respect not only for the capricious behavior of the Rio Grande, but for the menace of arroyo floods. It is not likely that they deliberately would locate a village in the path of one of the latter, yet, even within the memory of living man, villages, dating from no one knows how far back, have been overwhelmed and partially buried beneath the debris of neighboring arroyos. These arroyos are probably of recent origin or at least they have become menacing in recent times. It is a common story in this region that on the mesa to the east of Dona Ana in the Mesilla Valley of the Rio Grande, where now even a goat has difficulty in foraging a living, it used to be the custom of the natives to harvest a hay crop. Near the town of Las Cruces, New Mexico, is an arroyo which some day may engulf the town, but which 20 years ago had a bed six to eight feet lower than to-day, as is proven by adobe buildings partially buried in the sands it has brought down.

These are some of the more immediate and easily recognizable effects. What is the cause? Can it be that rainfall is heavier and more intense? Undoubtedly climate does change in cycles of both primary and secondary frequencies, but there is no evidence that the past 50 years has been one of the major cycles of heavy rainfall. Rather, is the cause not to be sought in that disturbance of the delicate balance of nature brought about first by uncontrolled and excessive grazing, second by the wide-spread destruction of predatory animals which feasted on rabbits and rodents, and all resulting in such rapid destruction of native grasses and herbage by cows, sheep, goats, rabbits and rodents, to say nothing of grasshoppers, that this sparse but nevertheless protective blanket of native vegetation no longer was effective in preventing surface erosion, no longer was the retentive top soil and root growth effective in retarding run-off, and in an ever-descending spiral we have the effects of erosion widening and deepening.

Private interests and the state and federal government have expended vast sums of money in the construction of irrigation projects in the Southwest. These projects, which are centers of civilization and Anglo-Saxon culture in the vast expanses of desert, are now viciously attacked by all those natural forces released when in any manner nature's delicate balance is destroyed. Reservoirs established across torrential streams for the impounding of flood waters are rapidly filling with silt brought in by the main stream and by side arroyos; river beds below the reservoirs are slowly rising, due to the absence of scouring floods, which, prior to the building of the reservoirs, washed on down stream the debris from side arroyo inflows. Rising river beds mean rising water table with added menace from water-logging and seepage of river bottom lands, and added difficulties in finding and maintaining artificial outlets for surface drains which protect the irrigable land from seepage. It is no uncommon thing, therefore, to find great irrigation projects threatened by the effects of erosion, not only from the effects of direct overwhelming of lands by arroyo floods and debris, but the more insidious and equally fatal effects of silt in reservoirs, distributaries and river channels.

Palliative measures, such as attempts to control arroyo floods by detention reservoirs at the mouths of the arroyos or along their courses, are generally futile. No structure, except at prohibitive expense, can be erected to withstand and impound arroyo floods. Impounding reservoirs soon would be filled with debris, which would have to be removed from time to time at prohibitive expense to maintain the integrity of the reservoir. Any one familiar with these conditions knows that the control of arroyos and the prevention of the disastrous effects of erosion must be effected at the source, namely, in impounding run-off on the watersheds, where the floods arise and where most of the products of erosion originate.

The engineering problems involved in the control of arroyos are numerous and baffling. If it were a question only of controlling water, the problem would be greatly simplified. However, arroyos bring down enormous quantities of silt, sand and coarser materials, some of which may be boulders of many hundred pounds' weight. The ease with which arroyos move relatively enormous boulders probably can not be accounted for on the basis of velocity alone. A research problem of great interest would be to determine whether arroyo water, because of its excessive silt and sand content, might not have an increased specific gravity, enabling it to transport, through added buoyancy, material which otherwise it could not move. This same effect of possible increase in specific gravity of water due to excessive turbidity may account for the occasional difficulty found in the clogging of irrigation ditches by sand. For example, some two or more years ago, the Rio Puerco injected into Elephant Butte reservoir enormous quantities of a yellowish mud which persisted in suspension or possibly in colloidal form for nearly a year subsequent to the flood. This yellowish mud was carried with irrigation water to all parts of the irrigation system, and during this time more difficulty was experienced

with deposits of sand in certain of the distributaries than had ever been noted before.

From the engineering standpoint, it would not be difficult to design safety valve reservoirs on some of our larger arroyos, similar to those on the Dayton flood control project, which would prevent the occurrence of serious floods on the lands and improvements at the mouths of the arroyos, but it is probable that such reservoirs soon would be filled with arroyo debris which would destroy their effectiveness and require constant maintenance.

There also arises the puzzling problem of what degree of protection arroyo flood control works should provide. Obviously, 100 per cent. protection would be an expensive if not impossible goal at which to aim, because an extensive rain storm of more than average intensity and duration on the watersheds of some of our arroyos would be followed by floods which would overtop and probably destroy any man-made thing in their paths. Something less than complete protection would be the only practicable aim of the engineer in the design of a system of control works, and whether the expense would be justified would have to be determined by the value of property to be protected and by the acquiescence of property owners in a scheme for limited protection only. The most simple method of checking arroyo action is the construction of large numbers of small and inexpensive dams of brushwood or boulders or other local materials along the course of the arroyo and its various tributaries, for the purpose of destroying grade. These, however, merely would tend to check the final emergence of the coarser arroyo debris into the larger river channels, would in no way check the floods, but would merely minimize their peaks. They would have nothing whatever to do with the further erosion of denuded hillsides, and would not diminish the quantity of fine silts and sands ultimately carried into river channels or reservoirs. The first line of defense must always be the native vegetation, if it can be encouraged to reestablish itself on the mesas and the steep slopes bordering the drainage channels. We can never prevent rapid run-off from the steep slopes of the mountains and foothills, but on the flatter mesas which border the irrigated valleys we can minimize the tendency of the run-off to pick up and carry debris by encouraging the reestablishment of the native shrubs and grasses which in former times we know did minimize erosive action.

Here, however, we find ourselves hopeless and helpless. The vast areas which border the valley of the Rio Grande, for example, both above and below the storage reservoir, are areas on which neither the irrigators nor the Bureau of Reclamation can exercise control. Those who use these areas for grazing may, from an enlightened sense of self-interest, practise methods of grazing which will tend to maintain the ranges at least in their present condition, if not to improve the growth of vegetation by limitation of herds or by alternate methods of pasturing and rest of certain areas. Such methods, however, are possible only where the stockman or sheepman controls enough grazing area individually to make it worth while and possible to practise advanced grazing methods or perhaps artificial re-seeding. Where open competition exists, as it does on great areas of unfenced range, each strives to secure as much pasturage as he can before his neighbor arrives. There is not the slightest effort at control or conservation, and great areas are denuded of all vegetation and perhaps irrevocably ruined. Such areas soon show the most melancholy effects of erosion, great gullies appear, where formerly were gentle swales, the gullies and box canyons thoroughly drain the underground water from adjacent areas and the cumulative effects are soon apparent in absolutely arid adjacent areas, which formerly supported a good growth of grass.

It is argued by those who advocate state control of the present public domain that turning over these lands to individuals to have and to hold by sale or lease will not only restore the native herbage but will be a source of revenue to the state. The writer is not convinced that enlightened self-interest of the cattle and sheep men is sufficient safeguard to the vast interests menaced by further erosion on the great watersheds of our southwestern rivers, a considerable proportion of the areas of which is public land. On the vast land grants which dot the Southwest overgrazing and resultant erosion seem quite as apparent as on the public domain. If the cattle and sheep industry is in a state of depression it is easy to practise conservation of forage, systems of deferred grazing, the protection and development of overgrazed areas. Let the cattle and sheep industry enter a boom period and it is questionable if those who owned or controlled the watersheds of our great rivers and the myriads of arroyos and smaller streams would practise such conservation methods as would be likely to deny to them the participation in quick profits that general overstocking for a short time would bring.

The interests of those whose living and whose properties are in the river valleys are too serious and too extensive and mean too much to the state to be left to the mercies of private interests in control of the ranges and the quality of whose enlightened self-interest alone would determine whether the valleys eventually shall be overwhelmed by the effects of erosion or whether its effects shall be stayed by proper and intelligent control and use of the remaining public domain. Nor should the revenues accruing to the

state be allowed to influence the matter. Even though considerable, they always will be insignificant compared to the irreparable damage which will follow a failure to stay the effects of erosion.

Expenditures for administration and grazing control, expenditures for fencing, re-seeding, arroyo control, wells and tanks, expenditures rather than revenues should and must be the expectation for years to come from an enlightened and really intelligent effort to remove the menace of erosion. Do any of our Southwestern states wish to add to their already overburdened budgets an immense and continuing expense for rehabilitating vast areas of lands which now reflect the unenlightened public lands policy of the federal government for the past seventy years? Is it not the duty of the federal rather than the state government to evolve a plan and bear the expense for the restoration of its public domain and to remove the menace of accelerated erosion which its public lands policy has brought about and which now threatens private and public developments in the Southwest?

When erosion is brought under control, it will be time enough to consider revenues and the finer points of state *versus* federal supervision of what then will be land worth arguing about. The Forest Service has proven its capacity for organizing a system and a force for controlling conditions that affect erosion in the national forests and on the range lands included within their boundaries. Expand their duties, give them authority and funds to make a start at least in controlling erosion on the public lands which form the watersheds of our principal rivers. Every year wasted in fruitless discussion of state *versus* federal control sees more silt deposited in our reservoirs, higher river beds, more land seeped, more surface soil washed off the ranges, more progress made toward that not distant time when American civilization in the Southwest must give way before the relentless forces released when nature's balance was disturbed on the watersheds of this region.

If nothing is done soon to restore the conditions on the ranges which existed 60 to 70 years ago, one can see an unending, expensive and almost hopeless struggle to prevent the obliteration of farming communities such as those along the Rio Grande. The Bureau of Reclamation has announced as a policy that it can not and will not attempt to protect farm lands on its Rio Grande project from the effects of arroyo floods. It has a difficult enough problem in attempting to protect its canals, drains and other works from being overwhelmed by the debris brought down by arroyos, without carrying its policy of protection to adjoining farm lands. A glance at a map of the Rio Grande project, with its slender thread of green agricultural lands hugging the banks of the Rio Grande while vast areas of mesa and mountain land stretch away on either side, certainly will impress one with the utter futility of attempting to do anything in the way of protection or control at the mouth of the arroyos. Out on those stark denuded areas which border and drain into the river, a wide-spread storm of even average intensity would bring down a volume of water and debris sufficient to carry away everything in its path, sweep out or submerge the mightiest of man's puny efforts at protection and leave desolation where now is a highly cultivated and flourishing community.

Let us cease "fiddling while Rome burns," and with an awakened consciousness of what erosion means, not alone now but to the future of this Southwestern country, forget the selfish interests of the stockmen, sheepmen or any other group whose pretensions to a place in the sun clash with the public's interests in the physical preservation of the public domain. Let us renounce any thought of revenue either for the state or the nation at large until a program of erosion control, actively carried out, begins to show results; then we can begin to consider whether New Mexico or other Southwestern states might not well benefit from leasing and other privileges on the grazing lands within their borders.

On the other hand, we should not be unaware of the vast problem inherent in suitable control of range conditions brought about by the dispersion of the range area into state, government, railroad, land grant and private holdings. If there were no consideration other than this involved, the simplest solution would be for the government to cede its remaining public lands to the state, whereupon the latter under its police power would proceed in the public interest to dictate upon what conditions, where and to what extent grazing might be permitted either on public or private holdings, so that erosion would be stayed and a progressive improvement in vegetative cover be brought about that eventually might restore to some extent primitive conditions on the watershed areas.

We generally are too apt to be guided in our decisions on public policies by the question of revenue. There will be no revenue in our range lands for anybody unless erosion is checked, and if erosion is not checked, if exploitation and not conservation is to be the policy of the next seventy to one hundred years, future archeologists, roaming over this region, may discover deep beneath what will then be the valley floor of the Rio Grande, concrete structures bearing the letters U. S. R. S., which being interpreted will remind the lawmakers of that distant time that our government once undertook a far-sighted policy of reclamation by irrigation. It advanced millions for

the construction of great irrigation works, which the people who settled in the valley of the Rio Grande of that time painfully paid for. It neglected, however, to realize that nature intended this region to be a desert and it made no provision to protect these people from the relentless forces of nature which pressed in on them from every side. The winds covered up with sand what the waters failed to wash away. A permanent civilization in these river valleys of the Southwest must be founded upon control of the desert, just as methodically as we control the torrential rivers. The sooner this fact is realized, the sooner will our lawmakers have achieved a permanently successful reclamation policy.

CUTANEOUS SENSATION[1]

By Professor S. W. RANSON

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THIS is really a very elementary problem with which you all have had first-hand experience. You know the distinctly different qualities of the sensations of warmth and cold aroused by sudden changes in the temperature of the skin, and the very different sensation of touch which is evoked when a thermally indifferent object comes in contact with the skin. If the heat and cold are sufficient to damage the skin, if the object is applied with crushing force or if it is sharp and penetrates the skin a fourth sensation entirely different from all the others is aroused, and this you call pain. What happens in the skin in each instance, and how are the disturbances which are set up there propagated to the brain, and how do they then make themselves felt in consciousness?

In spite of the primitive nature of this problem it has not by any means been solved. I shall leave out of account entirely the most difficult part; how when these propagated disturbances reach the brain they give rise to conscious sensation, which appears to be something of an entirely different order than neural activity. I can not understand how such a thing as a sensation of warmth makes its appearance as a result or as a concomitant of the activity of certain nerve cells in my brain. I can only admit the fact and leave to the future, perhaps the far distant future, the problem presented by the relation of brain and mind.

But the first part of the problem can be solved. It should be possible to determine which of the several different types of sense organs situated in the skin are sensitive to warmth, cold and touch, respectively, and which respond only to those painful stimuli which carry a threat of injury. It should be possible also to determine how the disturbances, when once set up in the sense organs, are propagated to the spinal cord and brain. It is to some relatively new information on this subject that I wish to direct your attention to-night.

When mechanical, thermal and chemical stimuli of sufficient intensity are applied to the skin they evoke sensations of pain, and it was formerly thought that excessive stimulation of any cutaneous receptor was painful. But this view was quite generally abandoned when it was found that there were separate warm, cold, pain and touch spots in the skin. For more than forty years it has been known that the skin is not uniformly sensitive. This can easily be demonstrated by marking off with a rubber stamp one square centimeter on the front of the forearm and subdividing this into square millimeters. If this area is then explored for touch by taking a not too stiff hair and pressing the end of it against the center of each of these millimeter squares in succession it will be found that touch is felt in only about one out of five of the squares. That is to say, there are about twenty points in each square centimeter on the front of the forearm which are acutely sensitive to touch. It is quite generally believed that these points are the only ones that are sensitive to touch, in spite of the fact that if a stiff hair is used the contact can be felt in every square millimeter. This can be explained as due to the pitting produced by the stiff hair causing a deformation of the skin which extends to and stimulates a true touch spot.

By appropriate means it is possible to identify points which are acutely and specifically sensitive for cold, others for warmth, and still others for pain. Not every psychologist will admit the absolute specificity and fixed identity of these sensory spots, but all will admit their existence. And, entirely apart from any of the implications of the punctiform theory, the number of these touch, pain, warmth and cold spots in a given square centimeter of skin may be taken as the best available index of the receptivity of that particular region in terms of each of the four varieties of cutaneous sensation.

One of the chief stumbling blocks in the way of the punctiform theory has been the failure to establish a definite relation between these spots and the sense organs in the skin. Yet if the theory is true such a relation must surely exist. For the sake of

[1] Lecture before the Northwestern University chapter of Sigma Xi, on December 9, 1932.

simplicity I shall assume for the moment that each sensory spot contains a sense organ specifically sensitive to one of the four types of stimuli. Later on I shall present a brief summary of such evidence as is available.

When a sense organ is activated by an appropriate stimulus the state of excitation is propagated to the central nervous system along the nerve fiber of which that organ is the peripheral terminus. The nerve fibers, which are so small that they can be seen only with a microscope, are grouped together like the wires in a telephone cable to form nerves. We may next inquire, what is the nature of the excitation which is propagated along the nerve fibers and which when it reaches the brain manifests itself in consciousness as a sensation?

We know that this wave of excitation, which is called a nerve impulse, travels much too slowly to be an electrical current; and that when such impulses pass over a nerve, there is a slight rise of temperature which can be registered only by the most delicate thermocouple and that they cause the nerve to use minute traces of oxygen, give off equally minute quantities of carbon dioxide, and hydrolyze phosphocreatin.[2] The nerve impulse, therefore, involves chemical changes in the fiber. This is about all that is known concerning the nature of the nerve impulse. But physiologists, making use of a considerable amount of constructive imagination, have pictured it to themselves as follows:

A nerve fiber is surrounded by a plasma membrane which, when in the resting state, is polarized with an excess of positive ions on the outside and of negative ones on the inside. The nerve impulse renders the membrane temporarily permeable and depolarized. Positive ions in front of this permeable portion of the membrane stream backward through it and then forward to neutralize the negative ions on the inner side. This adjacent part of the membrane thus becomes depolarized, and, according to the theory, depolarization for some reason makes it permeable, and the positive ions beyond it can stream backward through it to depolarize in turn the next stretch of the fiber. In this way a wave of electrical and chemical change spreads along the fiber. This is the nerve impulse.

Now it will be obvious that if a wire were run from the active to a resting part of the fiber an electrical current should pass through it from the resting to the active part. This in fact occurs and it has long been known under the name of nerve action current. If one lead of a string galvanometer is attached to the nerve at A and another at B and a volley of nerve impulses is caused to pass down the fibers, when it reaches A there will be a flow of electricity through the galvanometer toward that point, and when it reaches B there will be a flow in the reverse direction toward B. The galvanometer will show a diphasic deflection. By sensitive electrical devices it is possible to record the time, when the impulses pass each of two points, and thus determine the rate of conduction. It is known from data obtained in this way that an impulse travels at different rates in different fibers. The rate may vary from 1 to 100 meters per second in different kinds of fibers.

Naturally the action current is very weak, but recently by the use of vacuum tube amplifiers of the radio type it has been possible to increase its strength very greatly so that the inertialess cathode ray oscillograph can be used as a recording device. By this method Erlanger and Gasser[3] have increased our knowledge of action currents in sensory fibers. We shall have occasion to refer to their work a little later on.

With vacuum tube amplifiers and a capillary electrometer, Adrian,[4] professor of physiology at Cambridge, has been able to record the action currents of individual sensory nerve fibers and for this brilliant work he has been awarded this year's Nobel prize in medicine. He was interested in learning whether he could find any difference in the nerve impulses responsible for the different types of sensation, but could detect none, except that pain impulses traveled at a slower rate than those for touch. The frequency at which the nerve impulses follow each other over a given fiber may vary from 5 to 100 per second, according to the strength of the stimulus, but Adrian has shown that when a tactile end organ is stimulated in such a way that it responds at maximum frequency over a long period of time it does not cause pain. There is nothing characteristic either in duration, frequency or rhythm of the nerve impulses responsible for one type of sensation as against another. There is nothing comparable to the dot-dash system of the Morse telegraphic code.

Since the messages which reach the central nervous system over sensory nerve fibers are all alike, their interpretation as tactile, thermal or painful sensations must depend on the particular centers in the brain which they reach and activate. It is not the type of impulse which is significant but the connections of the fiber over which it passes. The sense organ with which the fiber is associated peripherally

[2] R. W. Gerard, "Nerve Metabolism," *Phys. Rev.*, 12: 469. 1932.

[3] J. Erlanger and H. S. Gasser, "The Action Potential in Fibers of Slow Conduction in the Spinal Roots and Somatic Nerves," *Am. Jour. Physiol.*, 92: 43. 1930.

[4] E. D. Adrian, "The Basis of Sensation," Norton and Company, New York. 1928; "The Messages in Sensory Nerve Fibers and Their Interpretation," *Proc. Roy. Soc. London*, Series B, 109: 1. 1931.

and the center to which it conveys the impulse determine the nature of the resulting sensation.

We return then to a more detailed consideration of the sense organs and sensory nerve fibers.

Several types of sense organs exist in the skin, but certain technical difficulties stand in the way of determining which serve for perception of warmth and which for cold, for touch and for pain. To begin with not every one is willing to cut out a piece of his own skin to make the test. But Dallenbach[5] and his three associates, after they had satisfied themselves of the location and fixed identity of certain warm and cold spots on their arms, had a surgeon excise small squares of skin, each of which included a warm or cold spot, and subjected these to histological examination. They were not able to see in their microscopical sections any special types of sense organs which they could identify as warmth or cold receptors.

Within the last year Bazett[6] has presented evidence which is of importance for the solution of this problem. In one square centimeter of skin he accurately mapped and counted the touch, warmth and cold spots. By means of a thermocouple he estimated the rate of conduction of temperature changes in the tissue and, by comparing the data thus obtained with the time required after application of the stimulus before the sensations of cold or warmth developed, he determined very accurately the depth of the sense organs concerned. The points sensitive to pain were too numerous for accurate enumeration; but 38 touch spots were counted in one square centimeter. In histological preparations of the same region of skin removed during operation on a patient he found the well-known end bulbs of Krause present in 11 out of 100 millimeter squares, while in the subject of his psychological experiments 7 out of 100 such squares had been found sensitive to cold. The depth of the cold receptors, as estimated by comparing the time required for response with the rate of transmission of temperature changes in the skin as determined by the thermocouple, was 100 micra, and the depth of organs of Krause as determined histologically varied from 91 to 103 micra. In 100 square millimeters there was one organ of Ruffini, and in the same area only one warm spot was found. The depth of the warmth receptor was estimated at 300 micra and that of the organ of Ruffini at 285 micra. These results together with those obtained by Strughold and Karbe[7] in their study of the cold spots of the cornea and conjunctiva make it evident that the end bulbs of Krause serve as cold receptors and the end organs of Ruffini as warmth receptors.

Where hairs are present, the nerve endings within their follicles serve as touch receptors.[8] In hairless regions the corpuscles of Meissner and the unencapsulated bulb-like endings described by Bazett probably serve the same purpose. The free nerve endings are quite universally regarded as pain receptors. They are the only endings present within the central parts of the cornea, where pain alone is felt.

The sensory fibers are long threads of protoplasm which arise from cells in the spinal ganglia. The single process of each cell divides into a peripheral branch which runs to the skin and a central branch which enters the spinal cord. Some of these fibers become enclosed in a sheath of fatty material known as myelin and for this reason are called myelinated fibers. Others have no fatty sheath and are known as unmyelinated fibers. The myelinated fibers vary in diameter from 1 to 16 micra, while all the unmyelinated fibers measure less than 1 micron.

The nerves supplying different regions of skin differ greatly in their composition, and this difference is related to the sensory capacities of the regions which they innervate. For instance, it has been found from a study of the nerves of an amputated arm that the median nerve at the wrist, which in proportion to its large size supplies a relatively small area of palmar skin richly endowed with tactile sensibility, contains a very high percentage of myelinated fibers and relatively few unmyelinated fibers. On the other hand, the medial cutaneous nerve of the forearm, which in proportion to its small size supplies a relatively large area of skin which is even more sensitive to painful and thermal stimuli than the palm of the hand but much less sensitive to touch, contains a very large percentage of unmyelinated fibers.[9] Furthermore, the majority of the myelinated fibers in the median nerve are large, while most of those in the medial cutaneous nerve are small. From this we may infer that touch is mediated by large myelinated fibers and pain by the unmyelinated and fine myelinated fibers.

These observations aroused our curiosity, and we decided to investigate nerves supplying still other areas of skin. In order to make a satisfactory comparison of the composition of a nerve with the sensory capacities of the area of skin which it supplies, it became necessary to have some quantitative statement of the sensibility of the different regions of the

[5] K. M. Dallenbach, "The Temperature Spots and End Organs," *Am. Jour. Psychol.*, 39: 402. 1927.

[6] H. C. Bazett, "Sensation," *Arch. Neurol. and Psychiat.*, 27: 489. 1932.

[7] H. Strughold and M. Karbe, "Die Topographie des Kältesinnes auf Cornea und Conjunctiva," *Ztschr. f. Biol.*, 83: 189, 201, 207, 297. 1925.

[8] M. v. Frey, "Die Haut als Sinnesfläche," Handbuch der Haut und Geschlechtskrankheiten, Bd. 1, Teil 2, S. 91. 1929.

[9] S. W. Ranson, "Cutaneous Sensory Fibers and Sensory Conduction," *Arch. Neurol. and Psychiat.* 26: 1122. 1931.

body in terms of the four varieties of sensation. Fortunately, we were able to find such a statement in recent papers from von Frey's laboratory in Wurzburg.[10] In that laboratory careful counts have been made of the four different types of sensory spots in many regions of the body. From their extensive tables I have extracted a few figures which show how varied are the sensory capacities of the skin in different regions. (Table 1.)

TABLE 1

Region	Number of spots per sq. cm. sensitive to			
	Pain	Touch	Cold	Warmth
Apex of nose	44	100	13	
Chest	196	29	9	0.3
Front of thigh	192	13	5	0.4
Front of forearm	203	23	6	0.4
Palmar surface of finger tips	60	100+	0.7	1.0
Back of fingers	100	9	8	1.7

Touch surfaces, such as the tips of the fingers and the tip of the nose, are relatively poor in pain spots and extremely rich in touch spots. The reverse is true of most of the remaining body surface. On the front of the thigh there are in each square centimeter of skin 192 pain spots and 13 touch spots, and on the front of the forearm 203 pain spots and 23 touch spots per square centimeter. On the touch surfaces there are from 44 to 60 pain spots per square centimeter as compared to from 100 to 200 in the same area on other regions of the body. Furthermore, on the touch surfaces there are about 100 touch spots as compared with 9, 23, 13 and 29 in other regions. Except in the territory around the mouth, warm and cold spots are comparatively few. If we may assume that the number of nerve fibers mediating each of the four varieties of sensation is proportional to the number of spots, we may say at once that the number of fibers mediating temperature sensations constitute an insignificant part of the total fiber content of sensory nerves, and that if pain and touch fibers differ histologically, it should be possible to see a striking difference between the nerves supplying a tactile surface like the palmar surface of the hand and fingers and those supplying regions like the front of the forearm. Such differences can readily be seen. The median nerve at the wrist, which supplies the palmar surface of the hands and fingers with high tactile and low pain sensibility, is composed chiefly of large myelinated fibers. The medial cutaneous nerve of the forearm, which supplies a region of low tactile sensibility very rich in pain spots, contains great numbers of fine myelinated and unmyelinated fibers. The inference seems clear that the large fibers mediate touch and small ones pain.

A detailed investigation of the cutaneous nerves, in which Dr. Droegemueller and Mrs. Davenport are participating and which is being aided by a grant from the American Medical Association, is now under way and has disclosed some interesting facts. To economize effort we have restricted the analysis to a single bundle or fascicle of fibers in each nerve. A fascicle in the medial cutaneous nerve of the forearm was found to contain 2,903 unmyelinated fibers, 563 myelinated fibers under 5 μ in diameter, 78 between 5 and 8 μ, and 273 more than 8 μ in diameter (Table 2). It is interesting to compare these data

TABLE 2

SENSORY SPOTS ON THE FRONT OF THE FOREARM AND NERVE FIBERS IN THE MEDIAL CUTANEOUS NERVE OF THE FOREARM

	Sensory spots in 1 sq. cm.	Per cent. of total spots	Fibers: Myelinated	Fibers: Unmyelinated	Per cent. of total fibers
Pain	203	87.3	(1–5 μ) 563	2903	90.8
Temp.	6.4	2.8	(5.1–8 μ) 78		2.04
Touch	23	9.9	(8.1–16 μ) 273		7.15

with the distribution of sensory spots in the region supplied by the nerve. There are 203 pain spots, 6 or 7 temperature spots and 23 touch spots in one square centimeter of the skin on the front of the forearm. Of the total number of spots about 87 per cent. are sensitive to pain, about 3 per cent to temperature and 10 per cent to touch. Of the total number of fibers, 90 per cent., including myelinated and unmyelinated, are under 5 μ in diameter, 2 per cent. have a diameter between 5 and 8 μ, and 7 per cent. between 8 and 16 μ. The agreement between the percentages of the different types of spots and of these three groups of fibers is very close and seems to indicate that pain may be mediated by the small fibers, touch by the large ones, and temperature sensations by those of intermediate size. It is only by including the un-

[10] H. Strughold, "Die Dichte der Schmerzpunkte auf der menschlichen Haut," *Ztschr. f. Biol.*, 80: 367. 1923. H. Rein, "Ueber die Topographie der Warmempfindung," *Ztschr. f. Biol.*, 82: 513. 1925. H. Strughold und R. Portz, "Die Dichte der Kältepunkte auf der menschlichen Haut," *Ztschr. f. Biol.*, 91: 563. 1931.

myelinated with the small myelinated that a sufficient number is obtained to account for the great number of pain spots. It is true that some of these small fibers are of sympathetic origin and are destined for the innervation of the blood vessels, sweat glands and smooth muscles of the hair follicles, but the majority of them are undoubtedly sensory and take origin from cells in the spinal ganglia.[11]

Table 3 shows the distribution of the sensory spots on the front of the thigh and of fibers in a nerve

TABLE 3

SENSORY SPOTS ON THE FRONT OF THE THIGH AND NERVE FIBERS IN THE LATERAL CUTANEOUS NERVE OF THE THIGH

	Sensory spots in 1 sq. cm.	Per cent. of total spots	Fibers: Myelinated	Fibers: Unmyelinated	Per cent. of total fibers
Pain	192	91.2	(1–5 μ) 1082	5824	94.17
Temp.	5.4	2.6	(5.1–8 μ) 161		2.19
Touch	13	6.2	(8.1–16 μ) 266		3.62

which supplies that area. The agreement is again satisfactory between the percentage of pain spots and small fibers and between the percentage of temperature spots and medium-sized fibers, but we are a little short of the large fibers for touch. A comparison of the distribution of the myelinated fibers of different sizes in these two nerves is instructive. The medial cutaneous nerve of the forearm which supplies skin having twenty-three touch spots per square centimeter has a higher percentage of large fibers than has the lateral cutaneous nerve of the thigh which supplies skin having only thirteen touch spots per square centimeter.

Gasser and Erlanger,[12] working on nerve action currents amplified by vacuum tubes and recorded by means of a cathode ray oscillograph, have furnished evidence of great importance. When cocaine is applied to a nerve, function is not lost all at once but gradually and in the following order: pain, cold, warmth, touch and motion. Analysis of the action currents shows that with this sort of block the small fibers are first affected, then those of medium size and finally the large fibers. When a pressure block is applied to a nerve, function is lost in the reverse order: motion, touch, cold, warmth and pain; and in this case the cathode ray oscillograph shows that the fibers are thrown out of function in the order of their size, beginning with the largest. The fine fibers and the sense of pain are the last to be affected by pressure and the first to be affected by cocaine. It is impossible to escape the conclusion that pain is mediated by small fibers, temperature sensations by those of intermediate size and touch by the large ones.

The threshold for direct electrical stimulation of small fibers is very much higher than that for large fibers. This is significant, since it has been found that when the electrodes are applied directly to the nerves, weak stimuli which could activate only the large fibers give rise to sensations of touch and that much stronger stimuli which could activate the small fibers are required to produce pain.[13]

Additional evidence pointing in the same direction is available from the phenomenon of sensory dissociation following nerve section in man and from the section of the fine fibers composing the lateral division of the dorsal root of a spinal nerve in the cat,[9] but since time is limited this evidence can not be presented here. Enough has been said to make it evident that progress is being made toward the positive identification of the sensory endings which serve as receptors for each of the varieties of cutaneous sensation and that the new evidence supports the current belief regarding the functions of these end organs. It is also becoming clear that the four varieties of sensations are mediated by different types of fibers—touch by the large myelinated fibers, temperature sensations by those of intermediate size and pain by the fine myelinated and unmyelinated fibers.

OBITUARY

FRANCIS LEROY LANDACRE

DR. FRANCIS LEROY LANDACRE, professor of anatomy and secretary of the College of Medicine of the Ohio State University, died at Columbus, Ohio, on August 23, 1933. His death removes from its faculty of medicine a veteran teacher and one of its most faithful servants and counselors.

Professor Landacre was born near Columbus, Ohio, on February 13, 1867. He attended Ohio Wesleyan and Ohio State Universities, receiving the B.A. degree

[11] S. W. Ranson and H. K. Davenport, "Sensory Unmyelinated Fibers in the Spinal Nerves," *Am. Jour. Anat.*, 48: 331. 1931.

[12] H. S. Gasser and J. Erlanger, "The Rôle of Fiber Size in the Establishment of a Nerve Block by Pressure or Cocaine," *Am. Jour. Physiol.*, 88: 581. 1929.

[13] P. Heinbecker, G. H. Bishop and J. O'Leary, "Fibers in Mixed Nerves and Their Dorsal Roots Responsible for Pain," *Proc. Soc. Exp. Biol. and Med.*, 29: 928. 1932.

from the latter institution in 1895. He began his academic career, the following year, as an assistant in the zoology department of his Alma Mater under the leadership of Professor David S. Kellicott, and as lecturer in embryology in the old Ohio Medical University. He carried this double load of teaching for many years. In 1902 he became professor of histology and embryology in the Medical School, and in 1908 professor of zoology and entomology in the Ohio State University. He was appointed professor of anatomy in 1914. During the summer of 1924–27, he conducted classes in neurology at the University of California.

It falls to the lot of few men to excel as a teacher and an investigator, but Professor Landacre's ability in both was soon recognized. He developed early in his career an interest in comparative neurology. This interest was sustained and stimulated by Dr. C. J. Herrick, who was during this period professor of zoology at Denison University, a neighboring institution. At Professor Herrick's suggestion he began a study of the origin of the functional components of cranial ganglia. After Professor Herrick was called to the chair of neurology in the University of Chicago, this association was continued. Professor Landacre studied at Chicago during the summer periods and received the Ph.D. degree in 1914. It was a happy circumstance that Dr. G. E. Coghill, who was also just beginning a study of the nervous system from the standpoint of its functional components, filled the vacancy at Denison University. His association with these distinguished neurologists determined definitely the course of his subsequent researches, for he undertook the task of studying the mode of development of the functional patterns of the nervous system, as revealed by these men in their investigations. His contributions in this field have dealt chiefly with the origin of ganglion components, the behavior of ectodermal placodes and the origin and fate of the neural crest. The recent verification of many of his findings by L. S. Stone, using experimental methods, was a source of great satisfaction to him.

It is difficult to comprehend the services of this man to the Ohio State University. During his thirty-eight years of service, he came in contact with thousands of students, who remember him as a profound thinker and a great but critical teacher. When the Ohio Medical University was incorporated in the Ohio State University as its College of Medicine, he was offered the post of professor of anatomy and chairman of the department. He accepted the appointment on condition that the Department of Anatomy be placed upon a proper academic basis. In the reorganization of the Medical School he pleaded vigorously for the establishment of university standards in all its various departments, clinical as well as preclinical. In the ensuing years, whatever he believed was beneficial to the Medical School as a whole, he vigorously championed, but as vigorously opposed any move to strengthen one department at the expense of another or any effort to modify or expand in personnel or student body if it meant a sacrifice of scholastic standards.

He was also deeply interested in pre-medical and pre-dental education. He served faithfully on curriculum committees and strove zealously to improve the training of pre-medical and pre-dental students. At his recommendation, the Department of Anatomy took over the teaching of comparative vertebrate anatomy and embryology in order to establish a closer correlation between pre-medical and medical anatomy —an arrangement which although unique has won the commendation and admiration of all his colleagues in American medical schools.

His most outstanding personal traits were his loyalty to his friends, his scientific sincerity, his devotion to and his admiration for scientific investigators, his adherence to principles without fear or favor, and his hatred of academic ballyhoo and hypocrisy.

R. A. K.

RECENT DEATHS

DR. HOWARD AYERS, from 1899 to 1904 president of the University of Cincinnati, formerly professor of biology at the University of Missouri, died on October 17, at the age of seventy-two years.

MAJOR R. Y. STUART, chief of the U. S. Forest Service, died on October 23 from a fall from a window on the seventh floor of the down-town building housing the national headquarters of the service. Major Stuart was fifty years old.

SAMUEL WASHINGTON MCCALLIE, since 1908 state geologist of Georgia, died on October 26, at the age of seventy-seven years.

DR. NELSON C. DAVIS, a member of the field staff of the International Health Division of the Rockefeller Foundation, an expert on yellow fever, died at Bahia, Brazil, on October 21, at the age of forty-one years.

DR. ALEXANDER QUACKENBOSS, since 1920 professor of ophthalmology at Harvard Medical School, died on October 27, at the age of sixty-seven years.

DR. ERNST VON KESSELER, employed in the plant protection department of the I. G. Werk at Leverkusen am Rhein, died suddenly in Cologne on August 29, 1933, at the age of thirty years. He spent 1930–

1931 at the Blandy Experimental Farm of the University of Virginia and 1931–1932 at the Experiment Station of the Association of Hawaiian Pineapple Canners in Honolulu as exchange student under the auspices of the Institute of International Education.

DR. LEON CHARLES ALBERT CALMETTE, subdirector of the Pasteur Institute, died on October 29, at the age of seventy years.

PAUL PAINLEVÉ, professor of analytical and celestial mechanics at the Ecole Polytechnique at the Sorbonne, Paris, three times premier of France, died suddenly on October 29, in his seventieth year.

SCIENTIFIC EVENTS

INTERNATIONAL CONFERENCE FOR THE PROTECTION OF THE FAUNA AND FLORA OF AFRICA

ACCORDING to the London *Times*, an international conference to consider measures for the protection of the fauna and flora of Africa met in London on October 31, in the Moses Room at the House of Lords. Lord Onslow, who was also the chief delegate of His Majesty's Government in the United Kingdom, presided.

The government was also represented by Sir William Gowers, senior crown agent for the colonies; Sir Arnold Hodson, the governor of Sierra Leone, and Mr. A. B. Acheson, of the Colonial Office. There were also representatives of the governments of South Africa and Southern Rhodesia.

Governments represented included the governments of Abyssinia, Belgium, Egypt, France, Italy, Portugal, Spain and the Anglo-Egyptian Sudan. The governments of India, the Netherlands and the United States had nominated observers to attend the conference. The secretary was Mr. Francis Hemming, joint secretary of the Economic Advisory Council. Assistant secretary of the conference was D. H. F. Rickett, assistant of the Economic Advisory Council. The address of the secretariat is 2, Whitehall Gardens, S.W.1.

The conference drew up a revised international convention for the protection of the fauna and flora of Africa. It will be recalled that a resolution was passed at the International Congress for the Protection of Nature, which was held in Paris in the summer of 1931, urging that the question of the negotiation of a new international convention should be considered by the powers concerned.

A draft convention had been prepared by the British government and circulated to the other governments participating in the conference to be used as a basis for discussion. This draft contains suggestions for an agreed declaration of principle on the subject of the establishment of national sanctuaries in which wild animals and plants may be preserved with due regard to the interests of the native inhabitants of the various territories concerned. It contemplates the adoption of concerted measures of control designed to restrict the killing of some of the rarer species of animals in Africa, and to prohibit the unregulated traffic in trophies obtained from such animals. It also deals with various objectionable methods of hunting and other practises which have a destructive effect upon wild life, and is designed to secure cooperation between the various administrations concerned and the free exchange of information on all questions relating to the protection of the natural fauna and flora of Africa.

It was expected that the plenary sessions of the conference would be held in public.

AWARD OF THE JOHN FRITZ MEDAL

THE John Fritz Gold Medal, highest of American engineering honors, has been awarded to the late John Ripley Freeman, of Providence, Rhode Island, as an "engineer preeminent in the fields of hydraulics and water supply, fire insurance economics and analysis of earthquake effects."

The award was made posthumously because of the sudden death of Mr. Freeman on October 6, 1932, during the procedure for his selection as a medalist. According to an announcement made by the Board of Award:

> Mr. Freeman made outstanding contributions to water power, water supply and other branches of hydraulic engineering, to fire preventive construction and protection of industrial buildings and to the investigation of earthquakes from scientific, structural and insurance points of view.
>
> A close friend has said that his earthquake study is an engineering contribution of the first magnitude, possibly, ultimately, to be recognized as his greatest achievement. These studies were pointed in part to getting an original basis for writing earthquake insurance, and in part to obtaining a better understanding of construction, both architectural and engineering, to resist earthquakes. He broadened the view and improved the method of attack of scientists in fundamental studies of earthquakes.

Mr. Freeman, whose activities extended all over the United States, to Panama, to China, and to other countries, was born at West Bridgeton, Maine, on July 27, 1855. He was graduated from Massachusetts Institute of Technology in June, 1876, with the degree of bachelor of science.

His early years were spent in hydraulic power work in New England. In 1886 he became connected with the Associated Factory, Mutual Fire Insurance Companies at Providence, contributing notably to the improvement of mill building and development of fire prevention apparatus, including automatic sprinklers, fire pumps and hose, as well as to studies of the causes of fires.

In 1896, he became president and treasurer of a group of fire insurance companies, with executive offices at Providence, and increased the insurance in these companies forty-fold, or from $65,000,000 to about $2,800,000,000, while reducing fire hazards and insurance costs for 6,000 leading American factories, in about twenty-five years.

Mr. Freeman had been a member of the Massachusetts Metropolitan Water Board, and chief engineer for improving the tidal estuary of the Charles River between Boston and Cambridge. He made investigations for the Metropolitan Park Commission of Massachusetts, and conducted an investigation of the water supply of New York City for Comptroller Bird S. Coler, in 1899. He was a member of the Burr-Hering-Freeman Commission on water supply for the City of New York, of the Rhode Island Metropolitan Park Commission and of the President's Commission on special problems of the Panama Canal relating to dam and lock foundations, sea-level versus lock canal and prevention of earth slides.

Mr. Freeman was one of the consulting engineers to the Board of Water Supply of the City of New York, which constructed the Catskill aqueduct and reservoirs. From 1917 to 1920 he was consulting engineer to the Chinese Government on improvement of the Grand Canal and regulation of the Yellow and other rivers to prevent floods. His consulting engagements included many of the large communities of this and other countries and important industrial corporations.

Mr. Freeman was president of the American Society of Mechanical Engineers in 1905, and of the American Society of Civil Engineers in 1922. He was an honorary member of both societies. In 1923 the American Society of Mechanical Engineers awarded him its gold medal "for eminent services rendered to industry in fire prevention." He was also active in many local technical societies. He was a member of United Engineering Trustees, Inc., of the National Academy of Sciences, and numerous other scientific and engineering organizations.

He received the honorary degree of doctor of science from Brown University in 1904, from Tufts College in 1905, from the University of Pennsylvania in 1927 and from Yale University in 1931. He was also made, in 1925, Doktor Ingenieurs, Ehrenhalber, der Sächsische Technische Hochschule, Dresden, Germany.

Members of the John Fritz Medal Board of Award are:

American Society of Civil Engineers—Thaddeus Merriman, Francis Lee Stuart, John F. Coleman, Herbert S. Crocker.

American Institute of Mining and Metallurgical Engineers—F. M. Becket, W. H. Bassett, Robert E. Tally, Scott Turner.

American Society of Mechanical Engineers—W. L. Abbott, Conrad N. Lauer, Roy V. Wright.

American Institute of Electrical Engineers—Bancroft Gherardi, W. S. Lee, C. E. Skinner, H. P. Charlesworth.

COMMITTEE OF THE AMERICAN ASSOCIATION ON THE PLACE OF SCIENCE IN EDUCATION

THE Council of the American Association for the Advancement of Science has authorized its Committee on the Place of Science in Education to prepare a one-day program to be given in Boston on December 29. The committee is authorized to invite to this program science teachers and representatives of organizations of teachers of science, and it is hoped that many teachers will be interested in attending. It is thought possible that those who attend will wish to take action relative to some kind of national organization of teachers of science.

Science teachers' organizations will be represented by appointed delegates and by any other members who may wish to attend. Individuals who are not members of organizations of science teachers or of the association are also invited.

Members of the committee are: Otis W. Caldwell, *chairman;* Karl T. Compton, E. R. Hedrick, Jerome Isenbarger, Burton E. Livingston and Morris Meister.

The completed program will be printed as part of the official association program. The preliminary program follows:

MORNING SESSION, 9:30 A. M.

At the Massachusetts Institute of Technology

Presiding Officer: E. S. Obourn, teacher of science, John Burroughs School, St. Louis.

Remarks on the Committee on the Place of Science in Education and its Function in Organizing the Program of the Conference. Otis W. Caldwell, *chairman* of the committee.

Reports of Experiments in Teaching Scientific Method: Discussion led by Homer W. LeSourd, teacher of physics, Milton Academy, Massachusetts; and a teacher of science in a secondary school to be selected. Open discussion.

The Science Teacher's Scholarship and Professional Training: Wilhelm Segerblom, teacher of chemistry, Phillips Exeter Academy, Exeter, New Hampshire. Discussion led by Ralph C. Bean, president, New England Biological Association; and Francis T. Spaulding, department of secondary education, Graduate School of Education, Harvard University. Open discussion.

Experiments with High-school Science Clubs: Morris Meister, chairman of the department of physical science, Haaren High School, New York.

Science Clubs in Relation to State Academies of Science: S. W. Bilsing, department of entomology, Agricultural and Mechanical College of Texas. Discussion led by Pauline Beery Mack, editor, "Science Leaflets," State College of Pennsylvania.

LUNCHEON, 12:30 P. M.

Presiding Officer: Jerome Isenbarger, teacher of biology, Chicago Public High Schools.

Some Reactions of Science upon Those Who Study It: John C. Merriam, president, Carnegie Institution of Washington.

AFTERNOON SESSION, 2:00 P. M.

Presiding Officer: H. A. Carpenter, specialist in science, Rochester Public Schools, New York.

The Work of the Central Association of Science and Mathematics Teachers: W. F. Roecker, teacher of science, Boys' Technical High School, Milwaukee.

Types of Useful Organizations of Science Teachers: W. L. Eikenberry, head of science department, State Teachers College, Trenton.

Are Further Organizations of Science Teachers Needed? An open discussion.

THE CAMBRIDGE MEETING OF THE NATIONAL ACADEMY OF SCIENCES

THE autumn meeting of the National Academy of Sciences will be held at the Massachusetts Institute of Technology on Monday, Tuesday and Wednesday, November 20, 21 and 22, 1933.

The sessions will be held in the lecture room of the George Eastman Research Laboratories of the Massachusetts Institute of Technology.

Luncheon will be served to members of the academy and guests on Monday, Tuesday and Wednesday at the Walker Memorial, Massachusetts Institute of Technology. On the afternoons of Monday and Tuesday, tea will be served in the Forris Jewett Moore Room, 6–321, and on Tuesday at Harvard University, in a place to be announced later. The subscription dinner on Tuesday, November 21, will be held at the Lowell House, Harvard University, at the invitation of Professor Harlow Shapley.

The provisional program follows:

Sunday, November 19

7:30 Dinner of the Council. Algonquin Club, Boston.

Monday, November 20

9:30 Business Meeting in Eastman Lecture Room, 6–120.

10:30 Welcome by President Compton and response by the president of the academy, followed by a scientific session. Eastman Lecture Room.

1:00 Luncheon for Members and Guests. Walker Memorial, North Hall.

2:30 Scientific Session. Eastman Lecture Room.

4:30 Tea in the Forris Jewett Moore Room, 6–321.

8:00 Public Lecture by Dr. Arthur E. Morgan, director Tennessee Valley Authority, on "Muscle Shoals and the Tennessee Valley Problem." Walker Memorial, Main Hall.

9:00 Reception by President and Mrs. Compton, at the President's House.

Tuesday, November 21

9:30 Scientific Session. Eastman Lecture Room.

12:30 Luncheon in Walker Memorial, North Hall.

2:00 Scientific Session. Eastman Lecture Room.

3:15 Visit to Technology and Harvard University Buildings. Arrangements will be made for visiting the various laboratories, libraries, museums, etc., of both institutions, by members of the academy and their guests.

5:00 Tea in the Forris Jewett Moore Room, Massachusetts Institute of Technology, and at Harvard University, in a place to be announced later.

8:00 Subscription dinner for members and guests, including ladies. Lowell House, Harvard University.

Wednesday, November 22

9:30 Scientific Session. Eastman Lecture Room.

12:30 Luncheon in Walker Memorial, North Hall.

1:30 Excursions to Round Hill and Oak Ridge, in case of sufficient demand.

SCIENTIFIC NOTES AND NEWS

THE new science building at Radcliffe College has been named William Elwood Byerly Hall, in honor of Dr. William E. Byerly, Perkins professor of mathematics, emeritus, at Harvard University, who served for more than thirty years as chairman of the academic board at Radcliffe.

DR. HERMANN WEYL, formerly professor of mathematics at Göttingen, arrived in New York on October 24 to take up his work at the Institute for Advanced Study at Princeton. He also plans to give a course of lectures at Swarthmore College. Dr. Weyl left Göttingen at the end of the spring term after the Hitler government caused several of his Jewish colleagues to be dismissed from the institution.

DR. JOSEPH S. AMES, president of the Johns Hopkins University, made the address on October 31 at a convocation of the University of Pennsylvania held in commemoration of the semi-centennial of the Graduate School of Arts and Sciences.

PROFESSOR HUGH S. TAYLOR, chairman of the de-

partment of chemistry at Princeton University, will be the first speaker under the A. R. L. Dohme lectureship for 1933–34 at the Johns Hopkins University. The lecture will be given on November 17 at 4:00 P. M., in Remsen Hall. The subject of the address is "Theoretical and Experimental Research Problems Involving Heavy Hydrogen."

ON October 24, Dr. J. O. Perrine, of the Bell Telephone Laboratories, lectured on television at West Virginia University, under the auspices of the West Virginia University Scientific Society. A dinner in his honor was given by the local chapter of Sigma Pi Sigma, the national honorary physics fraternity.

AT the graduation ceremony of the University of St. Andrews on October 6, the honorary degree of doctor of laws was conferred on Emeritus Professor J. E. A. Steggall, who has retired after fifty years' service in the chair of mathematics in University College, Dundee.

A GOETHE MEDAL has been awarded by the president of the Reichstag to Dr. Karl Sudhoff, professor of the history of medicine at Leipzig.

DR. ALEXANDER VON LICHTENBERG, of Berlin, has been awarded the Gold Medal of the International Serological Association.

WE learn from *Nature* that Dr. Edward Greenly has been awarded the Liverpool Geological Society's Medal, which is given for "outstanding geological work connected with problems bearing upon the work of the society." Dr. Greenly labored at his own expense for many years in the elucidation of the geology of Anglesey.

SIR LEONARD ERSKINE HILL, lately director of the department of applied physiology of the British National Institute of Medical Research, now director of research of the London Light and Electrical Clinic, writes to the London *Times* as follows: "On the retirement of Sir Edward Sharpey-Schafer from the chair of physiology at Edinburgh, at the age of eighty-three, his past and present assistants, twenty-nine in number, have published in his honor a special volume of the *Quarterly Journal of Experimental Physiology* composed of accounts of original researches carried out by themselves. Thirty-two papers are included in this volume and cover a wide field of interest. The final editing was placed in Sir Edward's own hands. His contributions to physiological science are stored in the libraries and utilized daily by research workers in further extending the boundaries of knowledge which he himself has done so much to advance right up to the time of his retirement. Every one knows of Schafer's method of artificial respiration, and many may be interested to know of the honor which old assistants, of which I am one, have tried to show him. We can never forget the friendship and wisdom with which he helped us on the way."

DR. J. B. LEATHES, lately professor of physiology at the University of Sheffield, has been made professor emeritus.

AT the meeting of the International Union of Geodesy and Geophysics, which was held at Lisbon, from September 17 to 24, the International Commission on Glaciers was continued. Of this commission Dr. Adolf Hoel, of Oslo, is *president;* Professor William H. Hobbs, of Ann Arbor, *vice-president,* and Professor P. Mercanton, of Lausanne, *secretary.*

AT a meeting on October 18 of the Indiana chapter of Sigma Xi the following officers were elected: *President,* Dr. Paul Weatherwax; *Vice-president,* Dr. Paul M. Harmon; *Secretary,* Dr. C. M. Louttit; *Treasurer,* W. D. Thornbury. Dr. H. T. Briscoe delivered the address of the retiring president, speaking on "The Last Two Decades of Chemistry."

RODOLPHE M. DE SCHAUENSEE has been elected a member of the Board of Trustees of the Academy of Natural Sciences of Philadelphia. This board, as now constituted, includes the following: Effingham B. Morris, *chairman,* Cary W. Bok, Charles M. B. Cadwalader, Clarence H. Clark, 3rd, R. R. M. Carpenter, Frank B. Foster, James E. Gowen, Thomas S. Gates, Prentiss N. Gray, George L. Harrison, T. Charlton Henry, E. R. Fenimore Johnson, Arthur E. Newbold, Jr., J. Stogdell Stokes and Harry C. Trexler.

DR. CHARLES S. MANGUM, professor of anatomy at the University of North Carolina Medical School since 1905, has been appointed dean to succeed Dr. Isaac H. Manning, resigned.

DR. BENJAMIN SPECTOR has been promoted to the head of the department of anatomy at Tufts College Medical School. Dr. Attilio Canzanelli has been appointed assistant professor of physiology; Dr. Max Ritvo assistant professor in radiology, and Dr. Harold A. Chamberlin professor of urology.

DR. WILLIAM J. FORDRUNG, Scarsdale, has been appointed head of the department of physiology and hygiene at Hunter College, New York City.

DR. GEORGE J. GOODMAN has been appointed instructor in botany at the University of Oklahoma. In addition to his teaching he will have custody of the state herbarium, a collection which at present consists primarily of a representative flora of Oklahoma.

WILSON R. MALTBY has been appointed bolometric assistant in the Smithsonian Institution. He relieves Walter Watson, Jr., at the solar radiation station at

Montezuma, Chile. Mr. Watson returns to Washington.

AT the invitation of the Academy of Sciences of the U.S.S.R., Dr. Hermann J. Muller, professor of zoology at the University of Texas, is spending the present academic year at the laboratory of the Academy of Sciences, Leningrad. Dr. Muller will also work at the Medico-Biological Institute of Dr. S. G. Levit in Moscow. Dr. Carlos A. Offermann will cooperate in the work at Leningrad.

PROFESSOR LOUIS C. KARPINSKI, who is lecturing in Europe at the present time, has been asked by the rector of the University of Athens to give a lecture early in November at the university. The subject of the lecture, which will be in French, is "Les Liaisons entre la Developpement de la Mathématique grecque ancienne et le Progrès de la Science et de la Civilization." He is also to lecture in English at the American College in Athens. In Cairo, during Thanksgiving week, Dr. Karpinski will lecture in French on "The Importance of the Ancient Egyptian Mathematics." In December he will lecture in Beirut and Jerusalem on "The Importance of the Arabic Mathematics" and on "The Importance of the Babylonian Mathematics."

JOHN C. PHILLIPS, associate curator of birds at the Harvard Museum of Comparative Zoology, sailed on October 22 to attend the International Conference for the Protection of the Fauna and Flora of Africa, in London.

WHARTON HUBER, associate curator of birds and mammals in the Academy of Natural Sciences of Philadelphia, has returned from a six months expedition to California, the object of which was to make a survey of the faunal geography of that state, with a special view to type localities. Through the courtesy of the California Game Commission, he was enabled to secure a number of interesting mammals for the academy's laboratory collections, including specimens of the dwarf elk which now is found only in Kern and Colusa Counties.

DR. HENRY E. SIGERIST, of the Johns Hopkins University, gave an address on "The Medical Profession through the Ages," at the New York Academy of Medicine on October 18.

DR. WALTER B. CANNON, of the Harvard Medical School, addressed the Society for the Advancement of Gastro-Enterology, New York City, on October 4, on "The Relation of the Nervous System to the Function of the Smooth Muscles."

PROFESSOR IVAN DE BURGH DALY, who has succeeded Sir E. Sharpey-Schafer in the chair of physiology at the University of Edinburgh, delivered his inaugural address on "Perspectives in Physiology" on October 11.

AT its October meeting the council of the American Academy of Arts and Sciences voted awards from its Permanent Science Fund as follows: To Charles V. Green, Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine, $500, to aid in his studies of tumor inheritance; to Gleason W. Kenrick, Tufts College, $500, for apparatus and assistance to aid him in studying the Kennelly-Heaviside layer; to Bret Ratner, New York University and Bellevue Medical College, $500, to assist him in his study of the anaphylactogenic properties of certain materials, and to V. M. Slipher, director of the Lowell Observatory, Flagstaff, Arizona, $750, to aid in the spectra of the planets. The next series of awards will be made in March, 1934. The address of the chairman of the Permanent Science Fund Committee is Professor E. M. East, Bussey Institution, Forest Hills, Boston, Massachusetts.

THE committees appointed by the Board of Overseers at Harvard to visit the Harvard Engineering School and other scientific departments "selected because of their interest in the success and usefulness of the department to be visited" include a number of scientific men. Dr. Irving Langmuir, associate director of the laboratories of the General Electric Company in Schenectady, New York, is a new member of the visiting committee for the Engineering School. The visiting committee on astronomy includes Dr. C. E. Kenneth Mees, of Rochester, N. Y., director of research for the Eastman Kodak Company, and Professor John C. Slater, of the Massachusetts Institute of Technology. George W. Merck, '15, a manufacturing chemist of New York City, has been appointed a member of the committee on chemistry. Alfred L. Loomis, banker and physicist, of New York City, is a new member of the committee on physics. F. Trubee Davison, president of the American Museum of Natural History, has been appointed to the committee for the Harvard Museum of Comparative Zoology. The two new members of the committee on zoology are Dr. E. Amory Codman, '91, and William P. Wolcott, '03, both of Boston. Clinton H. Crane, of New York City, naval architect, has been named to the committee on geological sciences.

To make it possible for its members conveniently to attend the Fourteenth Exposition of Chemical Industries, which is to be held at Grand Central Palace in New York City, December 4 to 9, 1933, the American Institute of Chemical Engineers has changed the dates of its national meeting to the following week. The meeting of the institute will now be held on December 12, 13 and 14. The place of the meeting, Roanoke, Virginia, is unchanged.

THE twenty-fourth annual Exhibition of Scientific Instruments and Apparatus under the auspices of the British Physical Society will be held at the Imperial College of Science and Technology from January 9 to 11, 1934. Evening discourses will be delivered during the exhibition by Mr. R. S. Whipple, on "The Evolution of the Galvanometer," Mr. J. Guild on "The Instrumental Side of Colorimetry" and Sir Ambrose Fleming on "The History and Development of the Thermionic Valve."

THE Committee on Scientific Research of the American Medical Association invites applications for grants in aid of research on problems bearing on the clinical aspects of medicine and surgery. Inquiries may be addressed to the committee at 535 North Dearborn Street, Chicago.

MISS M. D. RANKIN, Greenock, has given £20,000 to the University of Glasgow to provide a fund for medical research. The donor has expressed a wish that the claims of cancer research should receive special consideration, but apart from that the fund is to be available for any kind of medical research into the origin and curative treatment of disease. An executive committee of six members will be set up to administer the fund. A bequest of £8,000 has also been made to the university by the late Miss B. Aitken Gray for the endowment of a traveling bursary in engineering. With this fund a bursary will be instituted. It will be awarded by competition, and the successful student will be enabled to travel to study engineering achievements in different parts of the world.

A CORRESPONDENT to the London *Times* reports that the expedition to Abyssinia under the leadership of Mr. Wilfrid Thesiger has reached Addis Ababa. Mr. Thesiger is the son of the Honorable Wilfrid Thesiger, who was for ten years British Minister to Abyssinia. The expedition is supported by the Royal Geographical Society, the Percy Sladen Trust and Magdalen College, Oxford. The object of the expedition is to explore the still little-known Danakil country, which lies between the Abyssinian table-land and the Red Sea. The Hawash River, which rises in the mountains near Lake Zwai, flows down into the Danakil plains, and there is lost in the Aussa Sultanate. Its lower course has never been followed; its banks are covered with thick bush and the valley is extremely malarious. The region is inhabited by the nomadic, camel-owning Danakils, a warlike tribe akin to the Somalis, given to raids on the Abyssinians in the hills. The party will first undertake a short journey south of Addis Ababa to the headwaters of the Hawash River, to try out the caravan, and will then endeavor to follow the river to its end. They will make a compass traverse of the route and collect all possible specimens of mammals, birds and plants. Work will also be carried on for the Locust Investigation Bureau. The caravans will then be reequipped for a long journey north of the Simien Mountains, where the party will remain for about a month making further collections and endeavoring to get specimens of the Abyssinian ibex. This animal is only to be found in these precipitous mountains, which rise in places to a height of some 15,000 feet. The expedition will be away about nine months, and hopes to bring back a comprehensive collection of the varied Abyssinian fauna and flora.

ACCORDING to the *British Medical Journal*, the annual report of the council of the Royal Society of Medicine, presented to the recent annual general meeting of fellows, states that the roll of the society now includes 4,967 names, the great majority being those of fellows. The number of meetings of the society held last session was 166, comparing with 183 the year before. The number of readers in the library during the year was 44,391, and the number of books borrowed for home use was 28,679. The income of the society for the session was £22,473, an increase of £144 on the previous year, and it is explained that this relatively small increase in income is due to the fact that the financial crisis caused many more resignations than usual, though, fortunately, the accessions to the society outnumbered the resignations and deaths. The total expenditure was £506 less. At the request of the India Office the council of the society has considered the report of the Indian Drugs Inquiry Committee, and the Section of Therapeutics and Pharmacology has prepared a memorandum on the subject, which has been forwarded, through the India Office, to the Government of India.

DISCUSSION

GEOLOGICAL MISCONCEPTIONS CONCERNING THE OCEANS

CERTAINLY no phase of geology has been so neglected as the study of the ocean floor. Because of this neglect and because of scarcity of information up to recent times various ideas with very little basis in fact have taken form and become fixed in the writings and teachings of geologists. For example, one obtains the impression from typical text-books that the continental shelves are graded platforms which extend out from the shore to depths of approximately 100 fathoms (600 feet) where they are terminated by a steep slope, because this depth represents "wave base." The shelves are said to consist of wave-cut terraces inside and wave-built terraces beyond. The sediments on the shelves are supposed to be arranged

according to texture with gravel inside, sand beyond, and silt and clay covering the outer portions. Coastlines are classified as submerged if they have estuary inlets and emerged if they have elevated terraces. The presence of submarine valleys cut deep into the ocean floor beyond a coast is referred to as evidence that the coast has submerged recently. The deep ocean floor is described as being a monotonously flat plain over most of its vast area. Ten years of study of the geology of the oceans have convinced the writer that all the above statements are subject to grave doubt and that some of them are clearly erroneous.

Continental shelf profiles: Theoretically a smooth outward slope, somewhat concave inside and convex outside, is the profile of equilibrium which the waves would establish if they were allowed to operate undisturbed over a long period. Soundings of the shelves from all parts of the world show that such graded profiles are extremely unusual. The typical profiles show many irregularities, such as hills and depressions, and where soundings are closely spaced it becomes evident that there are a series of terraces separated by moderate slopes. These features are surely antecedent in origin to present conditions. In general, profiles show the broadest flat and gently sloping areas inside the 50 fathom contour, but the real steepening of the slope which represents the outer terminus of the shelf and the beginning of the continental slope does not come in most cases till depths of from 60 to 80 fathoms are obtained. It is unusual for the shelf margins to extend to depths of 100 fathoms. On the other hand, off glaciated coast wide areas, mostly on the inner and intermediate portions of the continental shelves, exceed 100 fathoms.

Wave-built terraces: Almost all geology text-books have a diagram of a wave-built terrace beyond a wave-cut terrace (Fig. 1a). Emerged wave-cut terraces are found along practically all coasts of the world, but so far as the writer has discovered from a perusal of the literature and from consultation of well-known students of coastal phenomena there are no clear examples of wave-built terraces with the relations which are depicted in the text-book diagrams. While this lack may be due to the removal of the wave-built portions during or subsequent to emergence, it seems at least as likely that the seaward moving products of wave erosion are distributed as fans at the terminus of the wave-cut terraces (Fig. 1b).

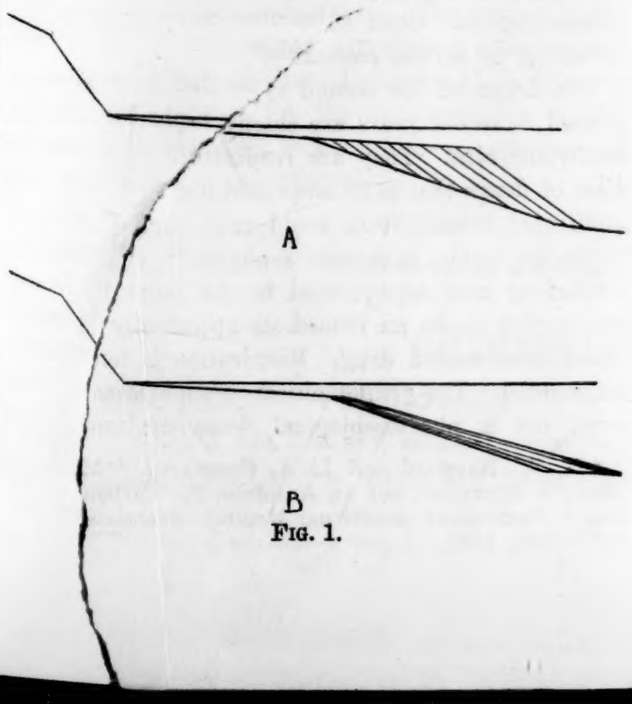

FIG. 1.

It seems improbable that the outer portions of the continental shelves are wave-built terraces on still other evidence. Most of the continental slopes are too steep and too irregular to represent the outbuilding of large masses of fine sediment from the land. The profound steep-walled submarine canyons which are cut into most of these slopes must certainly have rock walls, and various samples have indicated that this is actually the case. On the other hand, the gentle continental slopes off some large deltas, notably the Mississippi, may be sedimentary in origin, most likely representing the foreset slopes of deltas built during the low sea-level stages of the glacial period.

Continental shelf sediments: According to all available evidence, the simple gradation outward of coarse into fine sediment across the continental shelves is as rare as is the occurrence of graded topographic profiles.[1] Muddy sediments on the outer shelf are rather unusual, even off large rivers. The finest sediments are found in bays near shore, while the typical arrangement of sediment on the open shelves is patchy, with almost haphazard mixtures of mud, sand and gravel all the way to the outer margin.

Coasts of submergence and emergence: It is probably little or no exaggeration to say that an examination of the land in the vicinity of every indented coast cited as typical of submergence would reveal evidence of emergence and that examination of the sea floor adjacent to every coast with elevated terraces would reveal evidence of submergence. This statement is only surprising if one fails to appreciate the well-established changes in sea-level which must have accompanied both the forming and melting of the great continental glaciers of the ice age. Because of the vast ice sheets of Antarctica and Greenland which still exist the present is a time of intermediate sea-level. The last important change was the rise in the ocean which must have accompanied the melting of the last great ice sheets some 10,000 to 25,000 years ago. Since this rise was a world-wide phenomenon, most coasts should show evidence of a relative submergence. Exceptions might be found where shore processes had straightened the coasts or where

[1] F. P. Shepard, "Sediments of the Continental Shelves," *Bull. Geol. Soc. America*, 43: 1017–1040, 1932.

there had been more recent upheavals. Conversely, terraces up to about 200 feet above sea-level may have been cut by waves during interglacial epochs, due to a rise in sea-level accompanying melting of the Antarctic ice sheets.[2] Accordingly, it seems probable that most coasts which have been relatively free from Quaternary diastrophism should possess these common characteristics of both submergence and emergence.

Deep inlets along glaciated coasts: Fiords along mountainous coasts have been considered by most physiographers to be the product of glacial erosion,[3] but the deep inlets along hilly glaciated coasts are generally referred to as drowned valleys. Since these estuaries have depths in excess of any submergence which can be properly applied to post-glacial rise in sea-level, they might be evidence of real sinking of the land. There are, however, several reasons for doubting such evidence. These deep inlets are almost entirely lacking, except along glaciated coasts; their submerged portions are closely related in character to typical glacial fiords; and the adjacent coasts have strong evidence of post-glacial uplift of large amounts.

Submarine valleys and high terraces: Still greater confusion in the classification of coasts as submerged or elevated comes from the study of what appear to be wave-cut terraces hundreds of feet above sea-level and of submarine valleys thousands of feet deep.[4] Finding either the one or the other would be supposed to show definitely whether the coast had emerged or submerged. The difficulty lies in the discovery of both phenomena along many coasts. Geologists have claimed that there are high terraces along practically all coasts, and the charts show evidence of submarine valleys thousands of feet deep off most of the coasts of the world. If the high terraces were actually cut by the waves and if the deep submarine valleys were cut by rivers, it must mean that coasts have been very unstable and have been subject to great uplifts and depressions.[5] Before concluding that a coast has emerged or submerged on the basis of these two phenomena one should be sure either that only one or the other is to be found or that one process clearly anteceded the other and that evidence for the wave-cut terraces or the river-cut valleys is substantial.

Deep ocean floors: It is only in recent years that profiles have been made across the oceans with sufficient soundings to make it possible to judge the character of the ocean floor. The numerous transoceanic profiles made by the United States Navy and Coast Survey and by the German ship *Meteor,* all made by echo soundings, show that plains on the ocean floor are unusual and that irregular topography is much more common. The minor irregularities comparable to small erosional features on land may not exist except on the continental slopes, but it seems probable that there are more major irregularities and less monotonously flat areas than on the continents.

FRANCIS P. SHEPARD

FALSE REMEDIES FOR CARBON MONOXIDE ASPHYXIA

MANY investigators now misconceive the physiology of carbon monoxide asphyxia. Because of these misconceptions they suggest drugs that they believe should be cures or at least helpful. The drugs suggested fall into one or both of two classes: (1) Those that might assist the respiratory ferment of the tissues, and (2) drugs stimulating respiration.

The affinity of the respiratory ferment for carbon monoxide was found by Warburg to be very much weaker than that of hemoglobin. Even in an atmosphere of carbon monoxide deadly for man, only a negligible amount of combination with the respiratory ferment occurs. Substances like methylene blue can aid the respiratory ferment only in isolated tissues. When introduced into the living body they convert hemoglobin into methemoglobin, and render an additional fraction of the blood inactive for oxygen transportation. Such substances are synergists, not antidotes, of carbon monoxide.[1]

The drugs of the second type that have been exploited in recent years are chiefly alpha lobeline and methylene blue. They are respiratory stimulants: a class of drugs that is so large that out of it numerous additional investigators could each suggest his own "cure for carbon monoxide asphyxia." Of course an animal or man asphyxiated to the point of failing respiration shows an immediate apparently beneficial effect from such a drug. Respiration is temporarily augmented. The proper object in such cases is, however, not a pharmacological demonstration, but a

[2] C. W. Cooke, "Correlation of Coastal Terraces," *Jour. Geol.,* 38: 577–589, 1930. The tracing of terraces along the coasts at approximately the same level is questioned by some geologists.

[3] For a refutation of the proposed fault origin of fiords see D. W. Johnson, SCIENCE, n. s., 41: 537–543, 1915.

[4] Some writers have questioned whether the deep submarine valleys, like that off the Hudson, were cut by rivers, but recent surveys have shown that many of these features have river valley characteristics. See "Submarine Valleys" (*Geog. Review,* 22: 77–89, 1933) for a discussion of the various hypotheses.

[5] The large vertical range appears to exclude the possibility of these changes being due to fluctuations of sea-level during glaciation and deglaciation. The uniform levels of the continental shelves suggest that there has been a long period of stability since any great uplifts and sinkings such as may account for high terraces and deep submarine valleys.

[1] H. W. Haggard and L. A. Greenberg, "Methylene Blue: A Synergist, not an Antidote, for Carbon Monoxide," *Journal of American Medical Association,* 100: 2001–2003, 1933.

physiological restoration to health. No lives can be saved by such drugs that would not be saved merely by artificial respiration. Artificial respiration is harmless, in contrast to the ill effects of some of these drugs upon the heart. The only drug that can displace carbon monoxide from the blood, and replace it with oxygen, is oxygen. The only drug that can replace the carbon dioxide that the blood and tissues have lost, and recall the blood alkali into use in normal amount, is carbon dioxide. Carbon dioxide is also nature's own respiratory stimulant.

The treatment now used by the rescue crews of fire and police departments and of city gas and electric companies has demonstrated its effectiveness.[2] It consists of the inhalation of oxygen and 7 to 10 per cent. carbon dioxide. Unless the heart or brain is already severely damaged, resuscitation is almost always achieved. Many hundred inhalators for this purpose are now in use and are saving thousands of lives. The newspapers persist in calling these inhalators by the name of a discarded mechanical appliance, the "pulmotor." Every case of asphyxiation that recovers after a hypodermic injection of some drug is heralded as a brilliant cure. The victim would probably have recovered, and would certainly have felt much better next day, without the injection. Hypodermic medication in asphyxia is harmful rather than beneficial.

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CHROMOSOME NUMBERS IN FLAX (LINUM)

ACCORDING to Tine Tammes, of the University of Groningen, The Netherlands, common flax, *Linum usitatissimum,* has 15 chromosomes (haploid), as has also *L. angustifolium,* a species native to southern Europe and which may be crossed readily with the cultivated flaxes. M. Kikuchi, of Japan, found 9 chromosomes (haploid) in *L. perenne* of Europe and in *L. lewissi* of North America. The writer is indebted to Dr. A. E. Longley, Division of Genetics and Biophysics, Bureau of Plant Industry, U. S. Department of Agriculture, for the determination of the number of chromosomes in five additional species and varieties of Linum, as follows:

Linum rigidum Pursh. (Mandan, N. Dak.)	15	chromosomes (haploid)
L. sulcatum Riddell (Mandan, N. Dak.)	15	chromosomes (haploid)
L. perenne Asiaticum (Caspian Sea plains)	9	do
Flax, Hoshangabad (India)	15	do
Flax, Bison (N. Dak. Agr. Exp. Sta.)	15	do

It is noteworthy that the two species, *L. rigidum* and *L. sulcatum,* which are very different from common flax, have, however, the same chromosome number as *L. usitatissimum.*

The variety Hoshangabad, C. I. 40, was obtained in February, 1914, from the Central Provinces, India, and later as Indian Type 1, from Gabrielle L. C. Howard, formerly second imperial botanist for India. It also was obtained from Luther Burbank in February, 1918, under the name "Burbank Flax." This variety has very large yellow seeds and pale pink flowers. Bison is a new wilt-resistant variety of seed flax developed by the North Dakota Agricultural Experiment Station.

This note is reported so that Dr. A. E. Longley may have credit for these additional chromosome determinations.

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DANTE'S BONES

DANTE ALIGHIERI died in 1321 and was interred at Ravenna. Despite some vicissitudes, the bones of the poet seem to have been sufficiently cared for and kept marked. On the occasion of the 600th anniversary of Dante's death his tomb was opened and the bones committed for study to the care of Professor F. Frassetto, who with Giuseppe Sergi published a note on them in 1923. The definitive report has recently been published by Frassetto in a quarto of 205 pages with 95 figures. The cranium (without the lower jaw and teeth) is in excellent preservation and has been most exhaustively measured. The outline of the skull has been superimposed upon various extant busts of Dante. The fit is generally good except in the forehead; but then the existing portraits of Dante do not agree with each other and the fit with the Vela bust is excellent in all respects. The sumptuous volume can be obtained of Frassetto, University of Bologna, price bound ("di lusso, in pergamena") at L. 160.

C. B. D.

SCIENTIFIC BOOKS

RABER'S PLANT PHYSIOLOGY

CONGRATULATIONS are due any biologist when his book requires a second edition within five years; and further congratulations should be offered him when the second edition is such a marked improvement over the first.

Both of these statements apply to "The Principles of Plant Physiology" (The Macmillan Company,

[2] Y. Henderson, "Fundamentals of Asphyxia," *Journal of American Medical Association,* 101: 261–266, 1933.

1928, 1933), by Dr. Oran Raber. The first edition numbered 377 pages, the second has 432. The second edition is bound in warm red cloth, which should withstand laboratory wear better than the now unsightly green of my own copy of the first edition. It is a book to read and ponder; it is a statement of "principles," or fundamentals, or concepts, rather than a detailed guide to laboratory procedure. It presents the names and in twenty cases small photographic or other likenesses of contributors to the development of plant physiology. Six of these twenty are pictured in both editions, *viz.*, Willstätter, Molliard, Jost, Bose, Blackman, Dixon. Of these, three have profoundly influenced the thought of plant physiologists everywhere, by their individual contributions, while the other three have affected the study in their respective countries of France, Germany and India. The changes among the other fourteen are interesting to the professional plant physiologist, in many instances causing him to wonder, "Why?" But the inclusion in a book on a scientific subject of the likenesses of those who have contributed to it at once humanizes it. In the same way, the allusions in various places throughout the book to the contributions of plant physiology to human life are also valuable. And in this scientific book at least the author occasionally ventures a witticism. Thus in the course of a lucid discussion of respiration and its products one reads, "This would lead to the conclusion that plants in a sleeping room are not harmful and that one can continue to sleep in forests without danger of asphyxiation." Again "Saprophytism is living from life insurance."

The language of the book is excellent. The reviewer may express his individual dislike of the terms *cold* temperature, *warm* temperature, in place of *low, moderate* or *high temperature;* but everywhere the exposition is clear and concise, the subjects well chosen. At the end of each chapter one finds a set of questions. Are these needed, and are they by any means all that are suggested? Also at the end of each chapter are "References," under which one finds cited in full some of the contributions to the subject of the chapter. In the chapter itself the names of the authors, and in some instances the dates, but not the title or place of contributions—thus "Kahlenberg and True (1896) as well as Coupin"—are given. A professional botanist with library facilities would find no difficulty in determining and consulting these references; but those without adequate library equipment would be in difficulty. Furthermore, the papers or books cited in full under "References" are not all of greater value or importance than those mentioned in the course of the exposition. The reviewer fails, therefore, to recognize the basis of the treatment. As to the quotations taken from sources as varied as Tacitus and Eugene Field and used as chapter headings, are they appropriate as well as apt?

However, these are minor defects, individual, and the book is to be valued as source and stimulus.

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STANFORD UNIVERSITY

THE LITERATURE OF VERTEBRATE ZOOLOGY

An Introduction to the Literature of Vertebrate Zoology, Based chiefly on the Titles in the Blacker Library of Zoology, the Emma Shearer Wood Library of Ornithology, the Bibliotheca Osleriana and Other Libraries of McGill University, Montreal. Compiled and edited by CASEY A. WOOD. Oxford University Press, London, Humphrey Milford, 1931; 4to, pp. xix + 643; colored frontispiece. $15.00 or 3 Guineas.

SINCE books are ever of interest to the working zoologist, zoological bibliographies are well-nigh indispensable. So important a work as the present, giving as it does a catalogue of the zoological books in the library of McGill University, is worthy of special mention. It is, however, much more than a catalogue, since the first part of the three into which the book is divided is an attempt to trace the development of zoological literature from the earliest times to the present, with what success an examination of the pages readily reveals. Some of the interesting captions of the nineteen chapters in this part of the work convey an excellent idea of the contents and of the method of development of the subject: "The Beginnings of Zoological Records"; "Medieval Writers on Zoology and Their Immediate Successors"; "The Renaissance and Its Effect on the Records of Zoological Science"; "The Literature of Comparative Zoology"; "Travelogues of Explorers"; "Forerunners, Contemporaries, Followers and Successors of Linnaeus"; "From Natural Philosophy to Modern Biology"; "Some Important Zoological Treatises and Serials Published during the Nineteenth Century"; "The Literature of Zoogeography"; "Oriental Literature on Vertebrate Zoology"; "Periodicals and Serials on Vertebrate Zoology"; "Unique and Rare Printed Books, Manuscripts and Drawings in the Zoological Libraries of McGill University."

It is manifestly a great task that the author has set for himself, yet it is perhaps unfortunate that he did not find it possible to include all important literature in his treatment, rather than to restrict this to books in the McGill Library. However, the abundant material presented contains so much of interest and value

not only to the bibliographer, but to the working zoologist as well, that the reader forgets to be critical.

The "Students' and Librarians' Ready Index to Short Author-Titles on Vertebrate Zoology," which forms the second division of the book, aims to furnish the means of quickly finding the most important works on any subject in vertebrate zoology. To this end the authors, each with a word or two of catch title, are arranged chronologically under geographical headings.

By far the larger part (more than two thirds) of the book is devoted to "A Partially Annotated Catalogue of the Titles on Vertebrate Zoology in the Libraries of McGill University," and this forms the third section of the contents. In this catalogue the annotations include much information, such as obscure dates of publication and other items of value.

Of rare printed books the McGill University possesses so many that space does not avail to list them here. Of particular interest are the first edition (1680–1681) of Borelli's "De Motu Animalium"; the first edition (1570) of John Caius's "De Canibus Britannicis"; Scopoli's "Deliciae Florae et Faunae Insubricae"; and especially important for ornithologists, Blasius Merrem's "Beyträge zur Besondern Geschichte der Vögel gesammelt"; and the original editions of the two earliest (1544) bird books—Longolius's "Dialogus de Avibus," and Turner's "Avium Precipuarum."

There is also in the library a noteworthy collection of original manuscripts and unpublished drawings, some of the latter apparently unknown to the zoological world until unearthed for the McGill library by the activities of the indefatigable "compiler" of this published catalogue. Among the most interesting of these is the collection of 121 colored paintings of Indian birds executed early in the nineteenth century by Lady Elizabeth Gwillim. It now appears that she was the first ornithological artist to paint full-sized portraits of the very large birds, an honor heretofore always accorded to John James Audubon.

The present treatise catalogue makes evident that the several collections of zoological works contained in McGill University together comprise one of the most important scientific libraries in the western hemisphere, and zoologists owe Dr. Wood a debt of gratitude for making available a knowledge of these treasures.

HARRY C. OBERHOLSER

WASHINGTON, D. C.

SPHERICAL ASTRONOMY

Text-book on Spherical Astronomy. By W. M. SMART, ii + 414 pp. Cambridge University Press, 1931.

THIS book is an excellent text for a second course in astronomy in a liberal arts college, but it is not suitable as a text for a graduate course in spherical astronomy or as a reference book for the working astronomer. The wide range of topics treated, the inclusion of the recent developments in the subject, the excellent diagrams, the omission of troublesome details and the large number of problems enhance its value for the casual reader and for the elementary student. However, for one who desires a thorough treatment of the traditional problems of spherical astronomy, too large a part of the book is devoted to extraneous material, while many important details are omitted. For example, in chapter five about forty pages are devoted to a discussion of planetary motions. This adds to the completeness of the book from a pedagogical point of view, but the student of astronomy already has adequate treatments of this subject in the well-known book of Moulton and in that of Crawford. In the same class are portions of descriptive material normally treated in text-books of general astronomy, such as that of Russel, Dugan and Stewart: for example, parts of the discussion in paragraphs 25 and 84. Much of this space might well have been devoted to discussions of practical methods of computation, to critical examination of the formulae derived and to more thorough discussions of such topics as astronomical photography. Chapter one gives alternative proofs for the formulae of spherical trigonometry, but does not list them for convenient reference.

The most serious faults of the book are the lack of preciseness and the absence of references. As examples of the former we have on page 21 a discussion of "trigonometrical ratios for small angles" without mention of what is meant by "small," and on page 95, the statement that the error of a Shortt clock on any day "could be almost exactly predicted several months in advance." The redefinition of astronomical latitude, page 196, to mean geographical latitude is of a similar nature.

WALLACE J. ECKERT

COLUMBIA UNIVERSITY

REPORTS

ACTIVITIES OF THE ROCKEFELLER FOUNDATION

DURING 1932, The Rockefeller Foundation appropriated $11,577,064 for projects in the fields of the medical, social and natural sciences, the humanities and public health. A printed report on these activities has just been issued.

For public health work the foundation expended

during the year the sum of $2,539,057. It supported laboratories for yellow fever research in Lagos, Nigeria, Bahia, Brazil, and New York City; assisted the government of Brazil in an extensive program for the control of yellow fever; aided four states in the United States and the health administrations of 17 foreign governments in antimalaria work; conducted malaria studies in various parts of the world; assisted 10 foreign governments in antihookworm work, comprising laboratory and field programs; continued support for studies of tuberculosis, the common cold, undulant fever, yaws, schistosomiasis and typhoid fever; contributed toward the development of the central or local health services of 43 foreign governments; gave assistance to the central health administrations of 11 states and to the local health work of 164 counties in 22 states in the United States, and, finally, provided funds for the support of 225 international fellowships in public health.

The aim of the public health program is not merely to gain new knowledge of a limited number of diseases and public health problems, but by concrete demonstrations in the control of these maladies to fix attention upon problems of public health, to educate governments and to induce them to give increased attention to the fundamental health needs of mankind.

In recent years increased emphasis has been placed on careful correlation of studies of a disease in its environment with investigations in the laboratory. Through this procedure it becomes possible to make headway in the search for more effective and less expensive methods of disease control. Research is always conducted in cooperation with government health departments. When such research is successful the foundation aims to assist governments in preparing and trying out plans for the prevention of disease through application of the knowledge gained by research. More than 100 papers were published in the scientific press during 1932 and the early part of 1933, describing research work in public health problems carried out by members of the foundation staff or under foundation auspices.

High lights of the year in yellow fever work were the continued success of vaccination against yellow fever; the verification in the state of Espirito Santo, Brazil, of a mild epidemic of yellow fever occurring in the absence of *Aedes aegypti,* the usual mosquito carrier, and the clearing up of various moot points connected with the behavior of the virus in the mosquito and the usefulness of certain yellow fever laboratory tests.

In the field of the medical sciences, after 10 years of concentration on capital aid for buildings and on the endowment of certain medical schools, foundation emphasis during recent years has shifted to the support of specific research programs. In 1932 special attention was given to the field of psychiatry. The total amount appropriated for the medical sciences was $3,090,973.

The largest appropriation of the year in the medical sciences, $1,282,652, was made to McGill University, Montreal, Canada, for the establishment of a neurological institute. These funds provided for laboratory quarters and endowment for the departments of clinical neurology, neurosurgery, neurophysiology and neuropathology. In addition, many small appropriations were made in support of research projects in the field of neurology, elsewhere. Included among these were grants to the Kaiser Wilhelm Institute for Brain Research, at Berlin-Buch, Germany, and to the Institute for Psychiatric Research at Munich, for investigations of infections of the central nervous system; to the Institute of Physiology of the University of Bern, Switzerland, for research on the excitation processes in nerves, and to the London Hospital for training in neurosurgery.

Among other research projects in the medical sciences receiving support were studies of the physiology of the acoustic nerve at the Johns Hopkins University School of Medicine; studies of whooping cough at the Western Reserve Medical School; studies of virus diseases, especially of the nervous system, at Columbia University and at Washington University, St. Louis; biological research at the Radium Institute of the University of Paris, and investigations of the National Research Council Committee for Research in Problems of Sex. Funds were provided during 1932 for the support of 383 fellowships for the training of research workers in the medical sciences.

The main features of The Rockefeller Foundation's program in the natural sciences during 1932 were: aid to specific research projects, and support of a system of fellowships and travel grants. The work for which assistance was given during the year falls within the fields of paleontology, meteorology, astronomy, physics, chemistry and biology.

A grant was made to the International Commission for the Polar Year 1932–33 for the purchase of special equipment in connection with world-wide meteorological studies conducted by this commission. Aid was given to the California Institute of Technology for specific research projects in physics and chemistry. An appropriation was made to Harvard University for the furthering of chemical research in connection with the heat of organic reactions.

Aid was continued for studies which have been going on for some time at Chou K'ou Tien, near Peiping, China, where the remains of the prehistoric human being, *Sinanthropus pekinensis,* have been discovered. "Black earth" found in the cave from which

these remains were taken has been identified as charcoal. This carries with it inferences as to the use of fire by *Sinanthropus pekinensis*. A considerable number of quartz artifacts have been recovered. There can be no doubt that *Sinanthropus* was of truly human status. This maker of crude stone artifacts must have had hands differing in no essential respect from our own.

Among other institutions receiving aid were the Long Island Biological Association, the Zoological Station of Naples, the Perkins Observatory at Ohio Wesleyan University, the Institute of Inorganic Chemistry of the University of Göttingen, the Massachusetts Institute of Technology, the Palmer Physical Laboratory of Princeton University and Yenching University and Fukien Christian University in China.

Funds were provided for the support of 291 fellowships in the natural sciences.

The principal objective of The Rockefeller Foundation's program in the social sciences is the more effective analysis and better understanding of pressing social problems with a view to the improvement of the prevailing conditions of human life. The description of the year's work falls into two parts: a general program designed to promote certain interests in the social sciences as a whole, and a program of specific concentration in fields of special interest.

The general program includes four types of activity: the development of institutional (largely university) centers of advanced training and research; support of inclusive advisory and planning bodies, chief among which has been the Social Science Research Council in New York City; the provision of training and research fellowships, by which, in 1932, opportunity for advanced study was given through 56 fellowships administered by the Social Science Research Council and 167 fellowships under direct Rockefeller Foundation supervision; the maintenance of grants in aid and small projects, as well as certain larger undertakings of general interest such as the *Encyclopaedia of the Social Sciences* and *Social Science Abstracts*. All these types of activity were carried on abroad as well as in the United States.

The development of institutional centers of advanced training and research is regarded as the essential basis of the entire program. Nineteen institutions thus aided are listed in the annual report of the foundation. The research now recognized by university administrators as essential to progress in the social sciences is costly in terms of both time and money and has been greatly retarded by the economic depression. During 1932, new appropriations to centers of research included those given to the Universities of North Carolina and Texas, as well as to Stanford University and Harvard University.

In addition to the general program the foundation has supported social science research in three specific fields: (1) economic planning and control; (2) international relations; (3) social organization and procedure, with special reference to problems of community organization and planning.

Much physical illness, mental disorder, family disintegration, crime and political and social instability trace their origins to economic causes. In a time of depression, when millions of unemployed are unable to command the necessities of life, there is the incessant question as to why this distressing situation arises in a country where raw materials are plentiful, where technological equipment is of the best, and where workers are eager to apply their productive capacities. The foundation, although not itself a research agency in the social sciences, is impressed with the importance of research in this field. It therefore seeks to strengthen existing institutions which are collecting and appraising basic information and to assist in advancing particular studies which deal with problems of economic stabilization. For several years it has given support to various studies and organizations concerned with research in this field.

During 1932, substantial new grants were made by the foundation to a number of investigative organizations including Harvard University and the Universities of Pennsylvania and Minnesota. Smaller gifts were made to several foreign institutes of research. A large number of institutions were given support in carrying out programs in international relations and in community organization and planning. The total amount appropriated in 1932 for work in the social sciences was $2,622,567.

In the humanities the program of The Rockefeller Foundation during 1932 was directed toward the support of general research and advanced training of personnel and toward the promotion of projects having international significance. The centers of research and training aided included the Oriental Institute of the University of Chicago; the School of Oriental Studies, London Institution, University of London, and Yale University.

Grants in aid of specific research problems included support to the Institute of Archeological Research at the University of Michigan, which has been carrying on valuable excavations at the site of the ancient city of Karanis in Egypt; aid to the Prussian State Library in connection with a Union Catalogue, and aid toward important lexicographical work carried on by five learned societies of Germany and Austria centering at Munich, Germany.

Small sums were granted in support of definite projects of humanistic research carried out by mature scholars. The amount appropriated in 1932 was used

mainly for awards to foreign scholars. With funds contributed to the American Council of Learned Societies there have been provided 40 fellowships in the humanities. Seventeen of these were granted during 1932. All the awards were post-doctoral fellowships intended to provide opportunity for further training and experience in humanistic research. In addition a grant was made to the American School of Classical Studies at Athens, for fellowships in archeology, in connection with the excavation of the Athenian Agora.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE PURIFICATION OF MERCURY BY AN ELECTROLYTIC METHOD

IN addition to the many uses to which mercury is put in chemical and physical laboratories, it is becoming increasingly important in biological work as a confining and transferring agent for aqueous solutions and gas mixtures. After exposure to rubber tubing, stopcock grease and solutions of organic matter like blood, mercury acquires impurities, so that when it is shaken with water, large quantities of dirt, consisting of organic matter and mercury compounds, are liberated. Since large quantities of mercury are often needed at one time, a rapid and convenient method for cleaning it is desirable. After extensive experimentation with a variety of procedures, we have found the following method to be most satisfactory in combining effectiveness and convenience. The apparatus is inexpensive and easily prepared and the purification of 500 cc of mercury can be completed in one and one half hours.

In general the procedure is to make the mercury the positive pole of a 110 volt direct current, first in the presence of 10 per cent. H_2SO_4, then in the presence of 5 per cent. NaCl, and finally to make the mercury negative in the presence of 10 per cent. H_2SO_4, and to remove by filtration the scum which forms on the mercury during each of these steps.

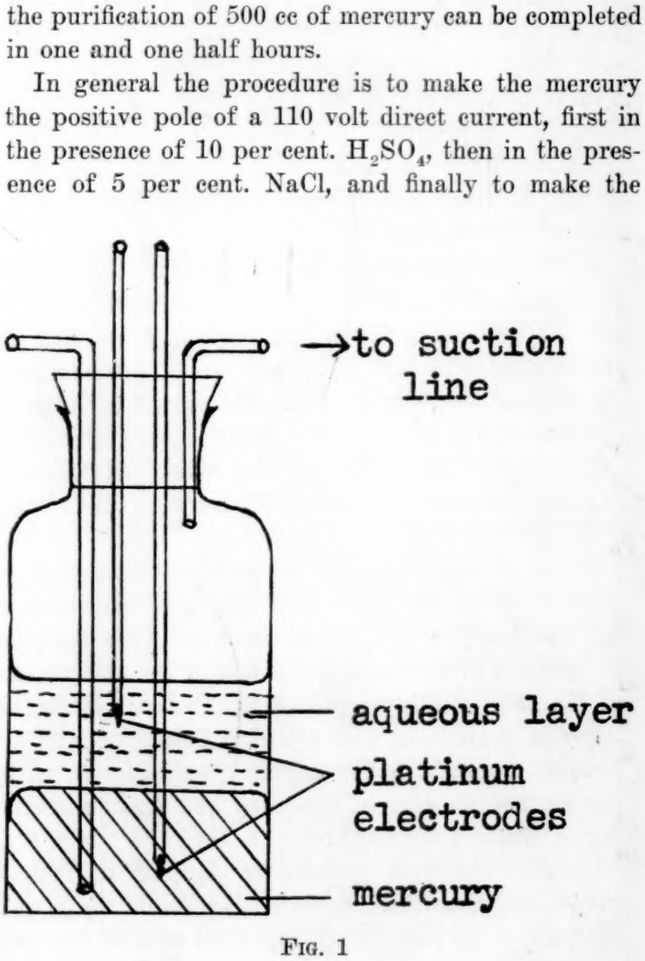

FIG. 1

APPARATUS

The apparatus consists of a wide-mouth bottle with capacity about four times the volume of the mercury to be purified, fitted with a stopper containing two glass tubes with platinum electrodes sealed in the ends, and containing also inlet and outlet tubes for air, the former reaching the bottom of the bottle, the latter ending close under the stopper. Platinum wires 0.5 mm diameter and protruding about 10 mm from the end of the glass serve well as electrodes. An ordinary water suction pump causes a stream of air to pass through the bottle, which not only agitates the mercury vigorously but also prevents the accumulation of explosive mixture of hydrogen and oxygen arising from the electrolysis. The electrodes are arranged so that they can be connected to the 110 volt direct current outlets with sufficient resistance in series, by means of a hot plate or lamps, to give a current of about 3 amperes.

PROCEDURE

One volume of mercury[1] is placed in the bottle with an equal volume of 10 per cent. H_2SO_4. The stopper with electrodes and glass tubes is inserted and air is bubbled through the mercury. The circuit is completed in such a way that the mercury is the positive pole and the electrode in the H_2SO_4 layer is then the negative pole. The electrolysis is carried on for fifteen minutes, during which time a gray precipitate forms in the acid layer. The circuit is broken and then the suction line is disconnected.

The mercury is now washed with alkali in the following manner. Tap water is run into the bottle to remove most of the acid, after which the mercury is poured into a bottle just large enough to contain it so that the water and acid are almost completely removed. The mercury is then poured into a larger bottle containing about one fifth volume N NaOH, and the aqueous phase becomes dark. The mercury and NaOH are poured back and forth between two

[1] We have found it impractical to purify more than 500 cc of mercury at one time because the great weight makes manipulation inconvenient.

bottles four or five times in order to increase the surface contact of the mercury and alkali, after which the alkali is removed by pouring the mercury into a bottle just large enough to contain it. The mercury is washed with distilled water by pouring it back and forth between two bottles, using a volume of water about equal to the volume of mercury. The water is removed by decantation and any water remaining is sponged off with a towel. The mercury has a green to brown scum on it which is removed by filtering through a piece of filter paper which has been perforated at the tip of the cone with a needle.

The mercury is again put into the electrolysis bottle and covered with an equal volume of 5 per cent. NaCl solution and a second electrolysis is carried out with the mercury the positive pole. A wrinkled bluish film forms on the surface of the mercury, a dirty green precipitate appears in the aqueous layer, and the solution becomes alkaline. This electrolysis is carried on until a red-brown precipitate appears, which requires five to twenty minutes, depending upon the amount of impurities in the mercury. The precipitate may adhere to the walls of the bottle or may be suspended in the solution. The NaCl solution is removed with tap water, the mercury is washed with N NaOH, with distilled water, and then filtered as described after the previous electrolysis.

The mercury is again placed in the electrolysis bottle and an equal volume of 10 per cent. H_2SO_4 is added. The electrolysis is carried on for fifteen minutes, but this time the mercury is made the negative pole and the electrode in the sulfuric acid layer the positive pole. During this electrolysis the surface of the mercury appears clean and, except for gas bubbles, the aqueous layer remains clear and colorless. After this electrolysis is completed, the H_2SO_4 is removed and the mercury is washed with N NaOH, with distilled water, and filtered as before. Then the mercury is washed with about one fifth volume of 10 per cent. HNO_3 and again with distilled water. This washing with HNO_3 not only removes traces of alkali but apparently removes some scum and thus makes the mercury sparkle to an unusual degree. In order to remove the last traces of acid or alkali, we have found it necessary to drop the mercury in a fine stream through a 50 cm column of running distilled water. After the supernatant water has been removed by decantation and sponging with a towel, the last droplets of water are conveniently removed by pouring the mercury through a dry perforated filter paper.

Discussion

This procedure is the result of an extensive study of a variety of procedures for purifying mercury. If any one of the steps is omitted, or if the order of steps is rearranged, the mercury obtained is less pure than that obtained by the method as described. Also more extensive electrolysis, additional treatment with chemical reagents, distillation or aeration does not improve the quality of the mercury beyond that obtained by the method as described. By this method we have obtained mercury which looks clean, has a bright reflecting surface, is free from scum, has a high surface tension and does not adhere to the walls of glass apparatus. It forms only a very slight black precipitate when aerated with neutral water for 24 hours, as is characteristic of the purest reagent mercury.

The following theoretical considerations guided us in developing this method. That organic and metallic impurities in mercury can be removed by oxidation is an old idea, and preliminary experiments where impure mercury was shaken with $FeCl_3$ or $K_2Cr_2O_7$ showed that such reagents are very effective. The method of oxidizing the impurities by making the mercury the positive pole in a direct current electrolysis was then tried, and it was found that this electrolysis method is not only superior in removing impurities but also involves less loss of mercury by oxidation than does the use of solutions of oxidizing agents. The electrolytic method usually involves a loss of 2 to 4 per cent., depending upon how much impurity is present, whereas during aeration with ferric chloride the loss may be 10 to 15 per cent., with less improvement of the mercury. Further study showed that one electrolysis with an acid and one with an alkaline solution is more effective than any other combination, and the presence of the chloride ion during the alkaline electrolysis is especially effective. It was then observed that pure mercury treated by these oxidizing electrolyses would show more black precipitate when agitated with water than similar pure mercury not so treated, and it was felt that this might be due to the presence in the mercury of mercury compounds, perhaps oxides, formed in the positive electrolyses. These should theoretically be removable by a negative electrolysis, which would reduce such mercury compounds to metallic mercury. The observation that a final negative electrolysis definitely improves the quality of the mercury led us to include this step.

The scum removed by decantation and filtration after the first two electrolyses contains considerable mercury. When collected separately and treated with dilute nitric acid it coalesces to form globules of impure mercury. When enough is collected, it may be purified and a large fraction of it converted into pure mercury.

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SPECIAL ARTICLES

STROBOSCOPY BY MEANS OF IMPRESSED EYE MOVEMENTS OR MIRROR VIBRATION

THERE are two general conditions which have been met in producing stroboscopic effects. First, a series of impressions of similar objects appear at the same position on the retina. Second, there is a light stimulus which is intermittent at approximately the same rate as the number of objects passing a given point per second.

A familiar procedure in demonstrating stroboscopy is to revolve a disk with equidistant radii, shown in Fig. 1, and light it intermittently with a commercial

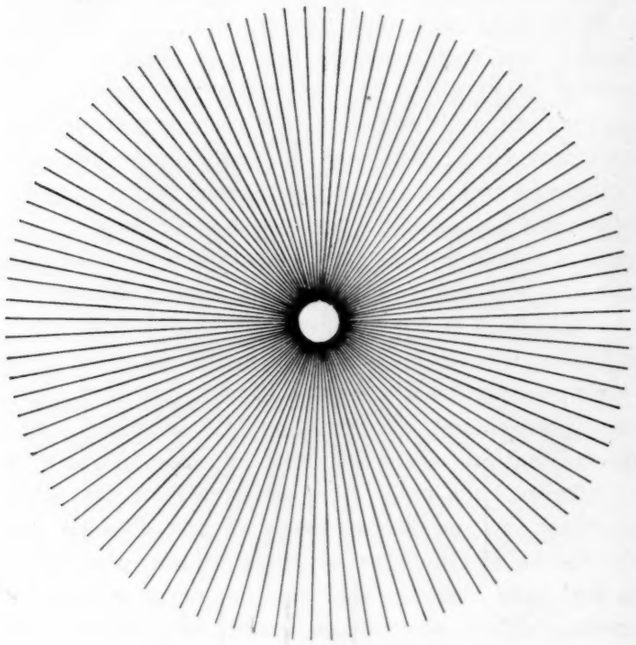

FIG. 1.

neon bulb placed in the A.C. lighting circuit. It is generally necessary to place the disk and neon bulb in a dark place. The disk has 100 radii and is revolved once per second on a phonograph turntable. An alternating current of 50 cycles per second gives 100 flashes of light per second, so that the number of radii on the disk passing a given point is the same as the number of flashes. Under these conditions the radii all come into view and appear to the eye to be stationary. The explanation is that, every time the light flashes, the imprint of the disk is the same on the retina. The successive impressions are fused because of retinal lag.

At the Ithaca meeting of the American Psychological Association in September, 1932, the writer read a paper explaining the method of producing stroboscopy by vibrating the eye instead of using an intermittent light stimulus. Since then it has been found that the same effects may be obtained by vibrating a mirror, viewing the effects in the mirror. Both procedures have their conveniences.

The original experiment was performed with a 50 dv. electrically-driven tuning-fork. It was pressed against the back of the head. When the disk with 100 spokes shown in Fig. 1 was placed on a phonograph turntable revolving 60 r.p.m., the spokes vividly appeared to be standing still. Any intense vibrator pressed against the bones of the head can be used.

If a vibrating tuning-fork is held against the bones of the head, the eye vibrates at the same rate as the tuning fork. Under such conditions, when one looks at a stationary field of vision, one sees the entire field in vibration, with two apparently stationary fields at the extremes of the vibration and a blurred field between. But looking at a stroboscopic disk with the number of radii passing a given point synchronized with the vibrations of the tuning-fork, one sees the radii. The radii in the direction of propagation of the impressed vibration show a slight elongation. An elongation of the disk radii in Fig. 1 to a distance of 1 mm from its center gives sufficiently satisfactory results. The actual amount of eye vibration is quite small.

The photographed vertical eye-movements of vibrations impressed by means of a barber's vibrator pressed against the back of the head are shown in actual size in Fig. 2 (the photograph has been inked).

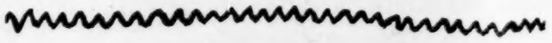

FIG. 2.

The device used was one designed by Mr. W. B. Clark in our laboratory. The motion of the light point image in the eye was amplified approximately 19 times. The retinal movement was calculated to be approximately .2 mm. Observers could detect no movement of the eye at the time of the picture, nor did the writer see any vibration of an after-image of the light source.

It has also been possible to use the voice directly as a vibrator of the eye, but this procedure ordinarily requires training, since the eye-movements are so slight. One sees "shadowy" radii, rather than the clear picture of the radii obtainable with a tuning fork or other electrical vibrator. The vibrations from the larynx are carried by means of bone conduction to the regions surrounding the eyes. The lower pitches, with their greater amplitudes, are more effective than the higher pitches. The following condi-

tions are aids to seeing stroboscopic effects by means of the voice:

(1) The stimulus objects should be long and narrow.

(2) The observer ordinarily should stand further away from the disk than his normal reading distance.

(3) The observer should experiment with the tilt of his eyes. The writer finds that looking at the disk from above with head up is most satisfactory. Evidently what could be called the "moveableness" of the eyes is dependent on the muscular relationships about the eye.

(4) Humming sends the vibrations up near the eyes. Holding a handkerchief to the nostrils makes possible a "bottling up" of the vibrations, letting the breath escape.

(5) The disk should be placed in a bright light, preferably direct sunlight.

The disk shown in Fig. 3 can be used for the determination of the pitch of the voice without any vibrating apparatus other than the voice itself. When placed on a phonograph turntable revolving at a rate of 80 r.p.m., the inner annular ring will appear to be standing still when low C is sung. The successive annular rings, from inside out, have radial lines, the number of which correspond (at 80 r.p.m.) to the number of vibrations per second of each of the half-steps of the even-tempered scale, international pitch.

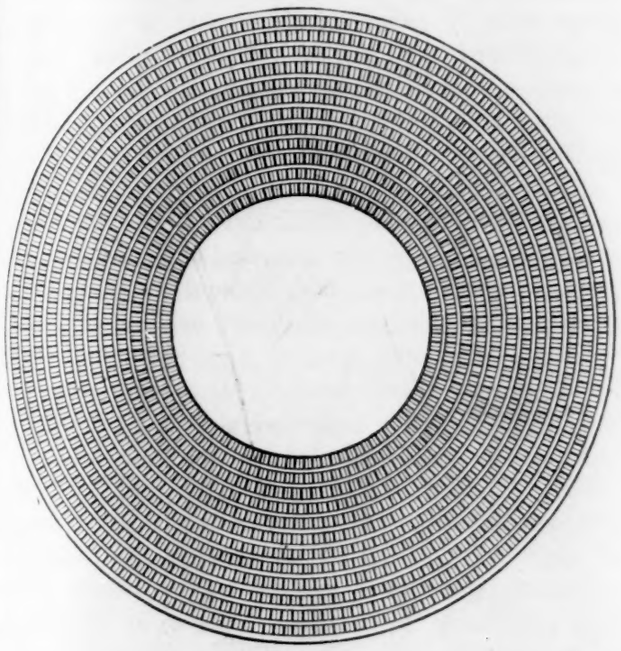

FIG. 3.

Another development which may be of interest is the photograph of the "natural period" of the eye shown in Fig. 4. The upper line is a photograph of the vertical eye-movements, and the lower that of the horizontal movements. The time marks represent 1/25 second. The bones to the left of the eye were tapped sharply once to get this effect. The rate of eye-movement is about twelve dv. per second. This may help to explain some of the stroboscopic results obtained in watching automobile wheels. If, in walking, the eye is jarred so that the successive impressions of the spokes are in the same or approximately the same place on the retina, the reported results are definitely and continuously obtainable. The jarring from jaw movements in talking likewise is effective.

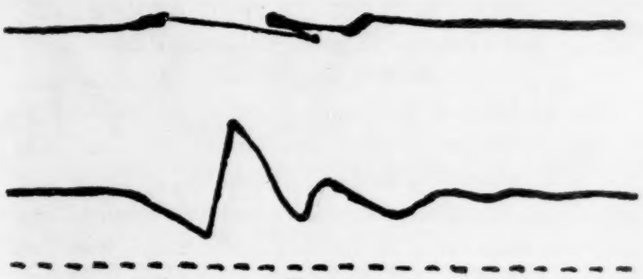

FIG. 4.

Several of us have been able to see the radii standing still continuously in shadowy form without any perceptible movement of the eye or body. Whether this is due to heart-beat, to an intermittent vision inherent in the visual process, or to some other cause we do not know at this writing. We used the disk in Fig. 1 revolving at 60 r.p.m. It should be emphasized that this effect is not the flash effect of the radii which one gets following a single eye-movement.

The use of mirror vibration for producing stroboscopy was first noted by observing the radii of Fig. 1 reflected from a shiny prong of a 100 dv. tuning fork. We are using mirrors on loud speakers instead of neon lights in measuring the pitch of the voice and other sound sources in connection with the disk on Fig. 3 and a new type of tonoscope. The advantages of this method are apparent, *viz.*, the singer need have no training in observation as in direct voice-eye vibrations, and he can observe pitch in the daylight of his studio instead of using a darkened room, as in the case of the present Seashore tonoscopes. The design of the new tonoscope is to be published subsequently with Mr. Harrison Musgrave, Jr.

To generalize, the explanations as to why stroboscopy is seen with both mirror and eye vibrations are similar. When the mirror is in rapid motion, the same vision cycle is present on the retina as in eye vibration. At the extremes of the vibration the visual field appears stationary, though actually intermittent. Between the extremes there is a blurring, also intermittent. Either eye-movement or mirror vibration provides intermittent stimulation of any given point of the retina, which is a necessary prerequisite for stroboscopic vision.

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REPRESENTATION OF IPSILATERAL-EXTREMITIES IN THE CEREBRAL CORTEX[1]

THE problem of the innervation of the extremities by the ipsilateral cerebral hemisphere has long been a very controversial subject. Recently, in the course of a series of experiments in which the cerebral cortex was stimulated electrically, movement was frequently elicited in the ipsilateral extremities.[2,3] Monkeys, *Macaca mulatta,* were largely used for the present study, although ipsilateral responses were also obtained in a few baboons, *Papio papio,* and chimpanzees, *Pan satyrus.* The "ipsilateral area" was sharply localized in the cerebral cortex. It occupied an area 3–4 mm in diameter about a point in the middle of the superior lip of the superior precentral sulcus. The center of this area was invariably the most excitable and on microscopical examination was always found to lie in the premotor cortex (Area 6 of Brodmann).[4] The entire excitable area, however, although lying largely in Area 6, extended slightly into the anterior part of the true motor cortex (Area 4). The threshold of this area for ipsilateral responses was always somewhat higher than the threshold of the true motor cortex or of the premotor cortex for contralateral responses. The responses elicited in the ipsilateral lower extremity usually consisted of extension at all joints although occasionally flexion, rotation, etc., occurred. Responses in the ipsilateral upper extremity were usually flexor in type and were much less frequently observed and more difficult to elicit than those in the lower extremity. Movement of the upper extremity, when seen, was most commonly obtained from just below the superior precentral sulcus.

In animals with intact spinal cords the ipsilateral responses were almost invariably associated with movements in the contralateral extremities of the opposite type, *i.e.*, extension of the ipsilateral lower extremity was associated with flexion of the contralateral. However, section of the contralateral half of the spinal cord in the mid-dorsal region abolished the response in the contralateral lower extremity without affecting that in the ipsilateral. This demonstrated not only that the two are independent phenomena but that the conducting pathway for the ipsilateral response occupies the ipsilateral half of the spinal cord. The elicitation of the ipsilateral response after removal of Areas 4 and 6, the main cortical motor projection system, of the opposite hemisphere and after section of the corpus callosum demonstrated that the response was not dependent upon the contralateral half of the encephalon.

The use of any of the barbituric acid derivatives as anesthetic agent or of deep ether anesthesia prevented the elicitation of the ipsilateral response. All experiments were, therefore, conducted under very light ether anesthesia.

Isolation of the "ipsilateral area" from the "leg area" of the true motor cortex lying just posterior to it, by an incision of the cortex, extirpation of the "leg" area or the application of novocaine to the "leg area," greatly enhanced the ipsilateral response. This was in accord with somewhat similar experiments of Dusser de Barenne and Marshall.[5]

Ablation experiments were in agreement with the results of stimulation. A remaining motor or premotor area in one hemisphere only is capable of integrating movement in the ipsilateral as well as the contralateral extremities, whereas an animal with the motor and premotor areas removed from both hemispheres is completely incapacitated.

Clinical experience in human cases supports the findings in the monkey. Foerster[6] elicited movement in the ipsilateral thigh by electrical stimulation of the premotor area of the human cerebral cortex, whereas a patient from whom Gardner[7] had removed the greater part of one cerebral hemisphere, including all of the motor and premotor areas, had sufficient use of the extremity contralateral to the extirpation to be able to walk with a cane.

The conclusions from these facts are that the motor and premotor areas of the cerebral cortex of primates are capable of integrating movement in the ipsilateral extremities and that in monkeys the area most excitable, electrically, for ipsilateral responses lies about the superior precentral sulcus in the premotor cortex.

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[1] From the Laboratory of Physiology, Yale University School of Medicine.

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[4] K. Brodmann, "Vergleichende Localisations lehre der Grosshirnrinde," Leipzig; Barth. 1090. 304 pp.

[5] J. G. Dusser de Barenne and C. S. Marshall, "On a Release Phenomenon in Electrical Stimulation of the 'Motor' Cerebral Cortex," SCIENCE, 73, 213–214, 1931.

[6] O. Foerster, "The Cerebral Cortex in Man." (Unpublished stenographic notes of lectures delivered at University College, London, April, 1931.) Brief résumé, *Lancet,* 2, 309–312, 1931.

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